HISTORY OF MANKIND
CULTURAL AND SCIENTIFIC DEVELOPMENT

VOLUME VI

THE TWENTIETH CENTURY

PART ONE

INTRODUCTION; THE DEVELOPMENT AND APPLICATION OF SCIENTIFIC KNOWLEDGE

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CULTURAL AND SCIENTIFIC DEVELOPMENT

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PART ONE

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CONTENTS

CONTENTS

PART ONE: THE DEVELOPMENT AND APPLICATION OF SCIENTIFIC KNOWLEDGE

Section I—New Scientific Thought

Section II—The Elaboration and Application of the Physical Sciences

Section III—Development and Application of the Biological Sciences

CONTENTS

INTRODUCTION: THE TWENTIETH CENTURY AS A PERIOD IN WORLD HISTORY

CHAPTER I

THE SHIFT IN WORLD POWER[1]

IN 1899 the British poet Rudyard Kipling wrote his famous lines: 'Take up the White Man's burden—ye dare not stoop to less.' In 1957 the African state of Ghana took its seat at the United Nations along with eighty other nations of the world. The history of the first half of the twentieth century is the story of the revolutionary shift in power reflected in these two events. For Kipling wrote not alone for the British empire, on which 'the sun never set', but for the French empire with its *mission civilisatrice*, and the Dutch and Belgian, the Portuguese and the German—in short for the white man of Europe who had carried his power and his civilization to the ends of the earth. And Ghana was not unique, for more than a dozen independent countries, formed by those whom Kipling had seen as the white man's 'burden', had already taken their places as sovereign equals in the family of nations.

The world which Kipling knew came to an end in the first world war. The sure hegemony of Europe in the world and the structure at home on which European leadership was based were damaged beyond repair by internecine strife, the shift in the centre of industrial society overseas, especially to the United States, the success of the October revolution in Russia and the mounting nationalism in subject areas spurred on by Europe's own enunciation of the principle of self-determination of peoples. To those who could read the signs, it was apparent that the old order could never be restored. But the illusion of the old Europe in the old world lived on for at least a decade after the war. Only when the great depression of the 1930s added helpless misery at home to political ineffectiveness abroad did those who had dominated both their own societies and their dependent peoples recognize that the world had basically changed. And even then the sense of superiority did not wholly die, but took refuge in the subconscious of many Europeans, where it hampered their ability to see what was really going on in the world at large.

The second world war ushered in the new age whose foundations had already been laid. At the close of the war two great powers, both the offspring of European civilization, dwarfed all others—the United States, which represented the fullest application of industrialism, capitalism and democracy, was prepared to give leadership to what it called the free world; the USSR, which had built a powerful industrial society by the application of communist principles and organizational techniques, aimed to become the most industrially developed country in the world and by its success to influence the direction of economic and political development of other countries.

In what had once been European colonies or spheres of influence in Asia,

the Middle East and north Africa, nations which had become newly independent or had been restored to full sovereignty struggled to overcome their handicaps of poverty and lack of economic development and to begin to catch up with the industrially developed countries. To this underdeveloped segment of the world the major contenders for world leadership offered economic aid and appealed for identification of interest, or at least friendly neutrality. The largest Asian country, China, chose the communist way, with the establishment of the Chinese People's Republic in 1949; so also did northern Vietnam and northern Korea. The rest remained outside of the communist orbit during the decade which followed the war, their constitutions drawn mainly on democratic lines, their economies a mixture of capitalism and socialism, and their policy generally one of non-entanglement in the major contest for power which divided the world.

The awakening of tropical Africa was not long delayed. In the new world that followed the second world war, no colonial power could take its position for granted and expect to escape for long the demands of its people: when Ghana achieved her independence, other African areas were already setting their timetables for their steps to statehood.

The old Europe in the new age found itself in a new role. On the one hand, the centre of gravity of European civilization had to a considerable extent shifted overseas, not alone to the United States, but to vigorous members of the British commonwealth, such as Canada and Australia, and to Latin America, where cultures of Portuguese and Spanish origins flourished as dynamically in Brazil and the Spanish-speaking American republics as in the Iberian peninsula. On the other hand European countries, forced back upon themselves, began to find a centre of gravity at home. By 1957 a nucleus of west European countries had agreed to develop a common European market and to exploit the new resources of atomic energy for their common use.

The world at mid-century had become in a very real sense a world society. Revolutionary developments in transport and communication had brought all peoples close to each other. The common language of science and technology carried the same meaning wherever it was applied. The common danger to life on earth from the radioactive effects of nuclear explosions was shared by all.

Though the world was sharply divided politically between the communist and non-communist groups,[2, 3] and divided economically between industrially developed and underdeveloped segments, the common problems of mankind had become the common concern of all. The United Nations provided, at the very least, a forum for world opinion. The World Health Organization united the forces of the world for the eradication of disease. The United Nations Food and Agriculture Organization concerned itself with the world's food and the welfare of the world's farmers and fishermen. The United Nations Children's Fund served children and mothers throughout the world. The United Nations Educational, Scientific and Cultural Organization supported efforts throughout the world to combat illiteracy and ignorance and sought to

strengthen scientific and cultural interchange. The employers, workers and governments of the world sat down together in the International Labour Organization to formulate labour standards. The Universal Declaration of Human Rights embodied an expression of the world's aspiration. Mankind at mid-century had awakened to a sense of world community in which all were inescapably involved.

I. HEGEMONY OF EUROPE

At the beginning of the twentieth century Europe still overshadowed the world. Two events may be taken as symbolizing this position: the occupation of Peking (1900) by the combined forces of European nations following the anti-foreign Boxer rebellion, and the Delhi durbar (1903) held to celebrate the coronation of King Edward VII of Great Britain. The first was a demonstration of the helplessness of the most ancient and populous state in Asia, a nominally independent nation, before the colonial powers of Europe; the second was a declaration of faith in the permanence of British power in Asia. China and India, containing between them more than a third of the population of the world, lay prostrate before the might of Europe, together with the domains of the French in Indo-China, the Dutch in the Indonesian archipelago and the subjects of the Russian tsar in central and north Asia.

The European powers, in the course of twenty years (1879–99), had divided among themselves virtually the whole of the African continent. The immense area of the Belgian Congo became the private property of King Leopold of the Belgians; central, west and east Africa were partitioned between Great Britain, France, Germany and Portugal; France extended her authority from Algeria to build up a Sahara empire and to exercise a protectorate over Tunisia; Italy occupied Somaliland and Spain claimed areas in the northwest. Only the historic empire of Ethiopia and the small American-sponsored republic of Liberia stood outside the sphere of European colonialism. The European powers had agreed on the general plan of partition at the Berlin conference of 1885, and had demonstrated by their suppression of such resistance as they encountered that wars against colonial peoples brought victory to colonial powers with little cost in men or arms.

There was at that time no apprehension, not even a faint idea, that a time might soon come when the European nations would have to withdraw from Asia, much less that they might one day be forced to grant independence to nations in Africa. Lord Morley, one of the most liberal statesmen of the time, declared as Secretary of State for India in 1908 that he could not foresee a time when India would be free and self-governing, and the Indian National Congress itself had claimed only 'self-government on the colonial pattern'. Kaiser Wilhelm II had voiced the assumptions of the powers who enjoyed semi-sovereign rights in spheres of influence covering the most fertile and valuable parts of China, when he boasted (1897) 'the German Michael has

set his shield, decorated with the imperial eagle, firmly upon the ground. Whoever asks him for protection will always receive it.'*

European hegemony appeared to rest not alone on armed might but on the advantage of European society by all the criteria which measured progress in an industrial age. In Europe were to be found the factories and mines, the

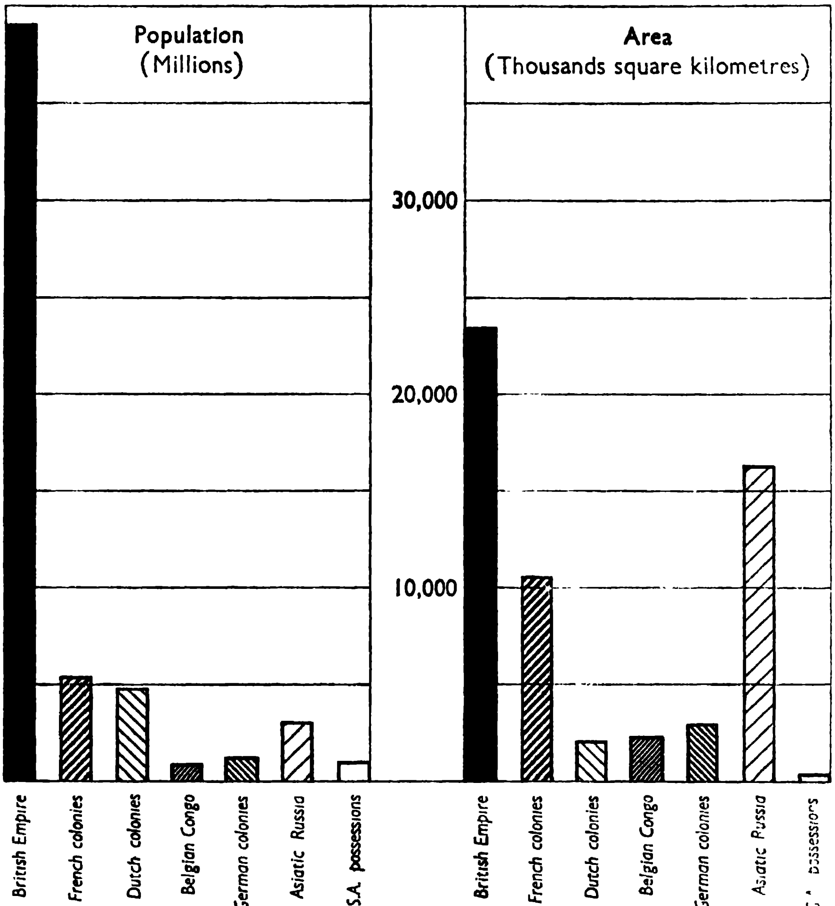


CHART I. Colonial Empires before World War I (1910–13).
Source: League of Nations. *Annuaire International de Statistique*, v.

railways and steamships, the machines and the harnessed energy that made up the sinews of an industrial society. The *per capita* consumption of the principal source of energy, coal, was one hundred times as great in Britain as it was in China. Viewed in human terms, the vast majority of the people of western

* William L. Langer, *The Diplomacy of Imperialism 1890–1902* (New York, Knopf, 1935), Vol. II, p. 459.

Europe were literate, while less than 10 per cent of their colonial dependants could read; they enjoyed an average life expectancy nearly twice that which prevailed in most of Asia and Africa. The disparity in productive potential and level of living appeared to mark the superiority of European civilization and to provide a basis for continuing dominance. Moreover Europeans, confident of the superiority of their Christian religion, displayed a missionary zeal that followers of other faiths lacked or could not express.

Only the Japanese empire remained outside the sphere of European authority, for the other free Asian countries owed their precarious independence to their status as buffer zones—Siam between Great Britain and France, Afghanistan and Persia between Great Britain and Russia. Once her traditional isolation had been broken in 1853, Japan had sought to acquire European techniques and to use them to defend herself from the fate which had overtaken the rest of Asia. Since 1868 she had pursued a vigorous policy of industrial and military development along western lines, and had combined the aggressive and dynamic spirit of the West with her strong central organization imbued with feudal traditions. Her victory over China in 1895 had placed her in a position to imitate the West in aspiring to become a colonial power in her own right.

The first significant breach in European supremacy came at the very time when Europe appeared to be at the height of its world power. In 1902 Britain concluded a treaty of alliance with Japan. This was a major event, looked at from any point of view. It was the first alliance on terms of equality between a great European power and an Asian state. It was directed frankly against another European state, Russia. Under its terms Great Britain was prepared to entrust to Japan the support of her vital interests in the area of the China Sea. The Russo-Japanese war was rendered possible only by this alliance.

The Japanese victory over Russia in 1905 may well be considered as the event which unleashed Asian nationalism. There had been earlier stirrings, as when Asian nations had received with enthusiasm the news that the Italian army had sustained a major defeat at the hands of the Ethiopians at Adowa (1896). But Italy was a little-known power in the East and though the Ethiopian victory showed for the first time that European nations were not invincible, it did not have the same revolutionary effect as the Japanese victory over the Russian colossus. Moreover the Japanese were victorious not only on land but at sea. Since the time when Khair ud-din Barbarossa commanded the Turkish fleet in the sixteenth century no Asian country had gained a naval victory against a European nation; in fact it was their sea power that had enabled the European nations to exercise authority in Asia. Admiral Togo's victory therefore appeared to most Asian observers as a turning-point in history, as indeed it was. In a short time the news of the famous victory even reached remote villages in Africa by primitive means of communication.[4]

The awakening of Asia may be said to start from that date. In India, especially, its effect was far-reaching. The nationalist movement, which

previously had asked only moderate reforms acceptable to some of the more enlightened British civil servants, became a revolutionary force. An extremist party, demanding complete independence and resorting to terrorism, violence and economic boycott as its methods, took the initiative away from the more moderate elements. In China the nationalist parties began, under the leadership of Sun Yat-sen, to plan a revolution.

Elsewhere the feeling was abroad that the time had come to prepare for independence. The nucleus of an independence movement was formed in Vietnam in 1909; a Burmese priest returning from a visit to Japan in 1914 called for a nationalist movement of renovation and liberation of Burma; in Indonesia a small group of western-trained intellectuals tried to revivify the old self-consciousness of the people without asking for help from the Dutch government. All this however might then have led to nothing more than partial reforms had not the war of 1914–18 broken the structure of European power.

That power had already begun to be counterbalanced by the rise of the United States as a world power. In 1900 the opposition of the United States, which insisted on an 'open-door' policy to maintain free access to the Chinese market, had helped to prevent the actual partition of China. In 1905 it was the president of the United States who mediated in the Russo-Japanese war; he proposed terms of settlement which limited the claims of the victor by denying the Japanese indemnity and returning Manchuria to China, and he brought the belligerents together to sign the Treaty of Portsmouth in a harbour of the United States. American investors were beginning to compete with British in Latin America and the nation had shown its readiness to invoke with increased confidence its historic Monroe Doctrine to prevent the intervention of any non-American power on the continents of North and South America.

The American people however were reluctant to enter the world struggle for power outside the continent which they had considered it their manifest destiny to occupy. When the Philippine Islands and Puerto Rico had fallen into their hands in 1898 as the consequence of pursuing their historic western hemisphere policy and aiding Spain's last dependency in the New World in its fight for independence, some leaders had welcomed the new role of the United States as a colonial power and others had accepted it as inevitable.[5] But many Americans, engaged in the task of settling a continent and cut off from Europe and Asia by broad oceans patrolled by the British fleet, retained their traditional desire to avoid entangling alliances. They, or their ancestors, had come to the new continent to escape the conditions of the old—its economic limitations, political or religious restraints, compulsory military service or direct persecution. To them America meant opportunity, not power. They were preoccupied with the quest for a life of freedom and well-being which seemed within reach, at least for their children, and they wanted no involvement in the affairs of Europe which they had resolutely left behind.

The industrial development of the United States was indeed already

showing signs of surpassing that of Europe in efficiency, productivity and extent. On the eve of the first world war, the United States was consuming 20 per cent more coal *per capita* than the most industrialized European country, Britain, and was producing 50 per cent of the world's machinery. It was the productive capacity of the United States that was to decide the issue when the European war had become a stalemate in 1917.

II. THE FIRST WORLD WAR—THE GREAT DIVIDE

The dominant position of Europe *vis-à-vis* the rest of the world belied the inner strains within Europe itself, where nations faced each other as from armed camps, and two systems of alliances perpetuated the old concept of balance of power. The enormous and ever-mounting sums of money and the manpower which European powers spent to maintain vast armies and navies were not designed to maintain their superiority over their subject peoples; colonial wars were cheap, and the subject peoples themselves furnished much of the manpower. The armed forces were aimed at European neighbours. Britain was determined to keep her fleet at the combined strength of the next two naval powers; France lengthened the term of conscription in the effort to bring the strength of her forces to those of her more populous neighbour, Germany, while the latter, in turn, increased the number of men under arms.

Once the spark was struck by the murder of the Austrian Archduke Ferdinand at Sarajevo on June 28, 1914, the continent was aflame. For a month efforts were made to localize the conflict, but when Austria finally declared war on Serbia one country after another was dragged swiftly into the fray. Within a week Russia had come to the aid of her ally, Serbia, Austria's ally Germany had declared war on Russia and her ally France, the frontiers of neutral Belgium and Luxembourg had been crossed by German troops and Great Britain, their guarantor, had entered the war. Italy refused to recognize a treaty obligation to the central powers, but subsequently came in on the other side when it appeared that she might use the opportunity to fulfil her irredentist ambitions in the Adriatic.

The conflict, moreover, did not remain European, for almost immediately after her own declaration of war on Germany Britain called on her ally, Japan, and in less than a month from the opening of hostilities in Europe the theatre of war was extended to the Pacific. Before the war was over, zones of combat included also the eastern Mediterranean, the Persian Gulf, the east and south coasts of Africa and the broad Atlantic.

The plans of all the military staffs were based on a short war. But new weapons had made the defence too strong for sudden victory, and within a few weeks the war had settled into a long stalemate which was not broken for nearly four years. As the war dragged on it became more and more a contest of peoples and of economic resources and less one of armies and navies. The submarine warfare by which the Germans sought to overcome the immense

superiority of the British navy destroyed merchant shipping carrying food and industrial supplies; the blockade of German ports starved the German economy of essential materials. Meantime the casualties from repeated efforts to break the stalemate reached staggering dimensions. By the close of the war more than two-thirds of the 39,000,000 men mobilized by France, Russia, Germany and Austria had been killed, wounded or captured, and over a third of the 14,000,000 British and Italian forces.

The European powers emerged from the war with their societies strained and weakened in every way: in men and wealth, in the balance of their economies and the stability of their political structures and above all in their relation to new powers rising or beginning to rise in other parts of the world.

As Europe's position declined the United States stood forth as a major world power. She finally abandoned her historic policy of non-intervention in Europe's struggles and threw her economic and military weight into the war in 1917, making a decisive contribution to the victory of the western allies. By the end of the war she had become a creditor instead of a debtor nation, and the world financial centre of gravity had started to shift from London to New York. Even more significantly, the United States defined the terms of the conflict, 'to make the world safe for democracy'; in President Wilson's Fourteen Points, she enunciated the bases for a peace settlement. The principle of the self-determination of peoples provided the rationale for the break-up of the Austro-Hungarian and Ottoman empires and encouraged the aspirations for independence among the peoples of Asia, the Near East and Africa.

Initiative in Asia also passed to the United States. When Japan faced China with her Twenty-One Demands at the opening of the war, it was the United States that opposed her. As a power concerned with open trade rather than colonial domination, the United States viewed the anti-colonial Asian point of view with considerable sympathy. In the era following the war the emergence of the United States as a major factor in the Far East impeded the complete resuscitation of European imperialism, for the colonial powers found that in the absence of American support it was no longer possible to follow 'gunboat diplomacy' as of old. American influence, furthermore, prevented a revival of the Anglo-Japanese alliance and effectively hindered Japan from organizing the resources of China in support of her own imperialist policies.

In the same year, 1917, that the United States entered the war Russia experienced the successive revolutions which ushered in the Soviet state. A decade earlier an abortive revolution had broken out following the defeat of Russia at the hands of the Japanese in 1905. In the intervening period stern repression and minor reforms had failed to quell the peasants' unrest or to check the radical tendencies of the active element among workers and peasants. In February 1917, with the war dragging on and Russian losses heavy, a revolution led by the liberal democratic and social revolutionary parties overthrew the tsar and sought to establish a liberal democratic régime.

Within a few months the revolutionary Bolshevik party of workers and peasants, led by Lenin, swept away the moderate government and seized power in the name of the proletariat. As the first successful revolution in the world to be projected in economic as well as political terms it had an immense impact internationally, for it provided a world-wide stimulus and encouragement to revolutionary movements of workers and peasants and gave an impetus and a socio-economic orientation to liberation movements among colonial and subject peoples.

In the civil war which followed the October revolution, the allied powers intervened to oppose the revolutionary party. The victory of the Bolsheviks in the civil war in spite of this intervention served notice that a new power had been born whose presence would have two profound effects. Not only would it have an unsettling influence on the traditional class structure of the capitalist societies of Europe; the USSR would in time overshadow the western European powers themselves when it stood out as one of the two giants of the modern world after the second world war.

But it was in its impact on the peoples of Asia and Africa that the first world war was perhaps most significant as a turning-point in world history. Once war broke out in Europe the unity of European interests *vis-à-vis* Asia was destroyed as the European nations began to bid for Asian support. Indian soldiers fought in France, and the entire propaganda machinery of the British government in India was utilized to prove to the Indians that Germans were inhuman 'Huns' and 'Boches'. Japan not only joined the war in Asia but was invited to send her navy to the Mediterranean. China and Siam were induced to declare war on Germany; China sent labour battalions to France and other theatres of war, and her allies actively encouraged her to abolish the rights of extra-territoriality and other privileges within China which Germany enjoyed.

The effect of Asians and Africans fighting in Europe in support of European nations against other European nations was unprecedented. The French statesman Alexandre Varenne, on his appointment as governor-general of Indo-China, noted that this participation had proved that peoples have other aspirations than physical well-being, it had awakened in distant lands of the ancient world a feeling of independence, and 'this Orient which the European travellers have discovered and crossed the seas to gaze upon has now crossed the same seas to view us and delve into the secrets of Europe'.*

More important than the actual discovery of Europe by Asians and Africans was the change in the moral position of the European powers. To ask India and Indo-China to subscribe to war loans in order to defend democracy and prevent the imposition of German *Kultur* over the world was to expose the moral weakness of the metropolitan powers to their own subjects. The Indian nationalist leader, B. G. Tilak, made this point clear when he

* Quoted in *L'Asie française* (Paris, March 1926), p. 110.

demanded openly that prior agreement on self-government for India was necessary before India could support the war as a national programme.

The preoccupation of European nations with war, moreover, gave the Asian nations their first major opportunity for industrial development. Japan alone was able to utilize the opportunity to the fullest extent, but industrial progress in India and China during the war period was considerable. The Indian iron and steel industry, for example, was able to establish itself firmly on a modern basis as a result of Britain's steel requirements in the East, and in the period immediately following the war, Indian capitalism began to assert itself and to compete with British capital in India. In China, though the country as a whole was disorganized, a new local capitalism found opportunities in the European concessions.

The rise of the United States and the Russian revolution both contributed to the dynamism of the war period in Asia. When President Wilson enunciated the principle of self-determination of peoples, it seemed like a new revelation. However much Europeans might have looked upon it merely as a useful weapon with which to detach the suppressed peoples of the Austrian, German and Turkish empires, it was acclaimed in Asia, where the European allies least desired it to be accepted, as a doctrine of liberation. When self-determination of peoples was accepted as a war aim the moral position of the nationalist movements in Asia became unassailable; for how could India, which had fought on the side of the Allies on three continents, be denied the right which was being offered to Czechs, Poles, Croats and Arabs within empires engaged on the other side?[6]

The Russian revolution gave strong reinforcement to Asian nationalism, and was a major factor in defining its content in the areas where a strong nationalist movement was not already defined in liberal democratic terms. The declaration of the rights of the peoples of Russia proclaimed the equality and sovereignty of the dependent peoples in the former tsarist empire, emphasizing the principles of national self-determination and ethnic separateness of minorities. This doctrine was highly explosive at the time, whatever its later application, and it had an immense effect in shaping opinion in Asia. Moreover, the Soviets from the beginning declared their support for the national struggles of colonial peoples, and they abdicated the rights of extra-territoriality which, with other European powers, they enjoyed in Asian countries. For the first time there was one European nation which was prepared openly to champion the cause of colonial peoples.

The impact of Soviet policy differed among Asian countries. In China Sun Yat-sen, after failing to secure European support for his parliamentary régime, openly declared: 'We no longer look toward the West. Our faces are turned toward Russia', and he patterned his party, the Kuomintang, on the Russian Communist party. The Indian National Congress on the other hand, with its liberal traditions of nearly forty years, was less impressed by the communist methods. The effect of the Russian revolution on India was mainly

to modify the content of nationalism, giving it an economic programme and an emphasis on social reconstruction. In areas where both the national economies and nationalist movements were less developed, as in Indo-China and Indonesia, the appeal of communism as such was greater.

Thus major elements that mark the new epoch in world history and separate it from the previous era had been brought together in the period 1914–18: the emergence of Asia as a factor in world politics, the growing prominence of the United States, the revolutionary character of Russia and the economic and political decay of the European powers. Few people either in Europe or elsewhere, however, realized how completely the situation had changed. It took the devastating economic depression of the 1930s to make it fully clear that the old European order had been permanently shattered. It required the ghastly trauma of the second world war to bring into precarious being the new world shape which, at the close of the first war, might already have been discerned.

III. BETWEEN THE WARS: THE SHADOW OF ECONOMIC DEPRESSION

1. *Decay in Europe* [7]

The end of the first world war left central Europe in a state of political disintegration after its superhuman effort to fight the combined power of the rest of the world. The once mighty German empire lay prostrate, its industries severely depleted, its currency in the grip of an unprecedented inflation through which the middle classes were virtually dispossessed. Germany was deprived of her Silesian coalfields and a reduced East Prussia was cut off from the main Reich by a corridor of Polish territory leading to the internationalized port of Danzig. The historic empire of the Hapsburgs was dismembered and the demands of its subject nationalities for independence were recognized. Czechoslovakia was set up, Yugoslavia was formed by the union of Serbia with Montenegro and parts of the Austro-Hungarian empire, while Austria and Hungary became separate, independent states.[8] The imperial capital, Vienna, great cultural centre of eastern Europe, was reduced to the level of a provincial city. Poland was reconstituted from its fragments which had been incorporated at the end of the eighteenth century into Russia, Austria and Prussia. The states of Esthonia, Latvia and Lithuania, which had long been part of the tsarist empire, were restored their independence.

The effect of all this was to create in the vital central region of Europe a number of small states, each jealous of its independence, and none with boundaries encompassing adequate economic resources or with a sufficiently strong political and industrial background to enable it to contribute to the stability of Europe.

France, with the prestige of victory, presented a brave front. But though the defeat of Germany left her as the first power on the Continent, the internal strength necessary to uphold her pretensions as heir to the power of

Louis XIV and Napoleon was not there. Her policy was dominated by the fear of a German revival and the recognition that once Germany found her feet again the dangers under the shadow of which France had lived from the time of the Bismarckian settlement would return in an aggravated form. Her former ally, Russia, which had been the counterpoise to German power, appeared to her to have become a potential enemy of western Europe;[9] the British and American guarantee on which France had hoped to build up her security did not materialize, for the United States Senate refused to ratify the Treaty of Versailles; the dream of the Rhine frontier for France was not realized.

French policy was therefore based on an organization of the smaller states of Europe—Poland, the successor states of the Hapsburg empire and the Balkan countries—under her leadership. The Little Entente was France's insurance, but clearly it could give no great support. Neither Yugoslavia, composed of conflicting nationalities, nor Rumania, which had a feudal political structure, could be a source of strength at a time of crisis. Czechoslovakia under the leadership of Thomas Masaryk and Eduard Beneš seemed a dependable ally. Poland appeared to have good military possibilities and French policy, consequently, was to try to develop a strong Poland.

Nor did the internal history of the Third Republic bear witness to a revival of strength. With the war sacrifice of 10 per cent of her active population killed and 11 per cent mutilated, and with an already low birth-rate further reduced, with most of her immense foreign investments wiped out by the Russian revolution and the finances of her client states precarious, her physical and financial position deteriorated perceptibly. These and other factors had their effects on the political fabric. Once peace was restored the political unity of wartime gave way to the characteristic political instability of the French parliamentary system. The popularity of extremist organizations, such as the royalist Action Française and the semi-fascist Croix de Feu, was evidence of a growing uneasiness, as was the growth of the Communist party; a series of political scandals revealed widespread corruption in French politics. A succession of ministries, notorious for their short term in office, proved incapable of dealing radically with the malaise of the nation.

When German revival became a reality and Adolf Hitler set out to tear to pieces the Treaty of Versailles, France found herself in no position to offer effective resistance. Hitler breached the French system of alliances by concluding a treaty with Poland in 1934; he denounced the clauses of the Versailles treaty requiring German disarmament and restored compulsory military service; he refused to continue to pay reparations; he reoccupied the demilitarized Rhineland and denounced the Locarno Pact of 1925 which had guaranteed the border between France and Germany. When civil war broke out in Spain in 1936 France lent no support to the legal republican government with which her own government was in sympathy, in spite of the aid rendered by Germany and Italy to the other side. In 1938, when Hitler

annexed the Sudetenland from Czechoslovakia, she stood by while her most valuable ally in central Europe went down. In the early months of the second world war, when the invading German armies outflanked the fortified Maginot line on which France had relied, she showed neither the ability nor the will to resist, and the collapse of France in 1940 was the end of the road down which this once great power had faltered in the inter-war years.[10]

The one European power which retained a semblance of its former character and position after the first world war was Great Britain. The British parliamentary system, deeply rooted in a centuries-old tradition, maintained its vitality. But the British empire only remained intact through its conversion into the British Commonwealth of Nations, and this very act revealed the extent to which power had shifted from the metropolitan centre to the dominions overseas. The self-governing dominions, Canada, Australia, South Africa and New Zealand, had sent their finest troops to the battlefields. They, together with India, claimed a share in the direction of the war, and the imperial war cabinet which included the prime ministers of the self-governing dominions and representatives of India marked a departure from the structure of the pre-war empire in which foreign policy, defence and the right to declare war were the exclusive privilege or recognized function of the mother country. At the peace settlement the dominions and India were accorded separate representation as major participants in the war.

In the years after the war the self-governing dominions claimed the right to act independently in foreign policy. At the Imperial Conference in 1926 a new relation between Britain and her self-governing dominions was formulated as that of 'autonomous communities within the British empire, equal in status, in no way subordinate one to another in their domestic or external affairs though united by a common allegiance to the Crown, and freely associated as members of the British Commonwealth of Nations'. The Statute of Westminster in 1931 confirmed this status and thus allowed the dominions to assume the rights of independent sovereignty with their own foreign policy and diplomatic representatives, though Britain at this time did not relinquish her hold on the Indian empire. While her people still thought in terms of her historic power, her position had already come to depend more on leadership than on dominance. The Irish rebellion during the war had forced the granting of dominion status to the Irish Free State on Britain's doorstep, and it could easily be foreseen that other self-governing or independent units would be formed from segments of the world-wide British empire.

One of the most significant symptoms of the decay of European power was the denial of democracy and the political values of western Europe by a large number of European nations. Beginning with Italy, where fascists under Benito Mussolini marched on Rome and assumed power in 1922, one European state after another, outside the ranks of the western and northern European countries, became anti-democratic and dictatorial in its government. Admiral Nicholas Horthy in Hungary (1920), Primo de Rivera in Spain

(1923), Marshal Joseph Pilsudski in Poland (1926), Augustinas Voldemaras in Lithuania (1928), Antonio Salazar in Portugal (1932) and finally Adolf Hitler's Nazi régime in Germany (1933) showed how great was the denial of the principles of democracy which had been the pride of Europe. In all these countries social unrest permitted dictatorships to rule. Once they were in power, irredentist claims made the dictators' ambitions a threat to stability and peace. The Italian d'Annunzio's romantic action against Fiume in 1919 was perhaps the incident that set the pace but it was only one among many claims, such as those of Poland to Teschen, of Lithuania to Memel, of Italy to Nice and Corsica, of Germany to the Sudetenland.

It was, however, the economic rather than the political weakness of Europe which finally revealed the changed position of the old European societies in the world and precipitated the chain of events which were to bring a radically new structure into being. The weaknesses and maladjustments of the European economies in the post-war years were in part concealed by loans from the United States which helped to carry Europe through the process of reconstruction. A struggle to maintain the value of the French franc produced a political crisis in 1926. In the same year deep-seated labour unrest in Britain expressed itself in a general strike with a larger number of participants than any other strike in history. But it remained for the great depression of the 1930s finally to sweep away the illusion that the world could be restored to its pre-war shape, with Europe the seat of paramount power and the European bourgeoisie the ruling class over colonies abroad and workers at home.

The collapse of the European economies from the precarious readjustment they had achieved in the years after the war was precipitated by the crash of the New York stock market in October 1929, which ended a speculative boom in the United States. The fact that this event could drag down the European economies in its wake was in itself evidence of their dependent state. Two years later, when a measure of confidence had been restored and some recovery achieved, the failure of the principal banking institutions in Austria and Germany sent the European and American economies plummeting further into the economic abyss, their currencies undermined, their industries shut down, their national production reduced by as much as a quarter to a half from its 1929 level, and millions of workers unemployed, their families hungry, their outlook without hope.

Whatever the factors involved in the collapse and in the failure of efforts to bring recovery—and these were still in debate a generation later—the effects of the prolonged depression were far-reaching. They revealed that after more than a century of industrial development the capitalist countries of Europe and America still had too little understanding of their own economies to keep their people continuously employed. The spread and prolongation of the depression throughout the world showed how extremely vulnerable the industrial economies had become to dislocating influences, wherever these might arise. The fact that Britain since the close of the war had had continuous unemploy-

ment and that her basic coal industry had been chronically depressed seemed to imply that the European economies might be suffering from fundamental and perhaps incurable ills.

The great depression thus shook the confidence of the European countries in their own societies, it exposed their inner weaknesses to the rest of the world, and it so preoccupied their statesmen with domestic affairs as to sap the vigour of their national policies abroad. It created a fertile soil for the rise of dictators ready to take unorthodox means to meet the crisis, and produced an atmosphere of international impotence which permitted them to pursue their ambitions unchecked.

Against this background of frustration and despair, Adolf Hitler rose to power in Germany in 1933 and embarked on the course that was to plunge the world into war six years later. Hitler's strength lay in the fact that he dared to imagine a wholly new order and to set out to remake the world in this image. The tragedy for Europe was that his vision was a denial of every value which European society and European culture had developed through the centuries. For reason he substituted 'thinking with the blood', and the 'big lie'; for democracy and ultimate confidence in the judgment of the common man, the 'leadership principle' and blind followership by the masses; for respect for individual worth and human life, unmitigated terror, even to mass use of the gas chamber in his campaign to exterminate millions of citizens who happened to be Jews; for the give-and-take of political controversy and the initiative of voluntary organization, the *Gleichschaltung* of all parties, organizations and groups under common direction and into a common mould; for freedom of thought and speech, repression; for freedom of conscience, subservience of the Church to the state; for the authority of law, the secret police—Gestapo—and the perversion of legal principles and practice to serve the leader's ends; for the concept of equality and the brotherhood of man, a hierarchy of roles, in which women were permanently confined to children and home, workers must give up their independent organizations, and the other peoples of Europe and the world must recognize their inherent inferiority and be prepared to bow to their natural masters, the German *Herrenvolk*; for the ideal of a civil order, the military ideal as the norm of society.

With this vision of a new order, he tackled the internal problem of the German economy and the external problem of Germany's status. By a vigorous programme of militarization he set the unemployed to work and converted a labour surplus into a labour shortage. His policy of autarchy to make Germany independent of world trade called for the development of new industries and substitute products to take the place of those from abroad. While the rest of Europe stood by, preoccupied with its struggles to pull out of the depression, he effected a union with Austria, eliminated its conservative clerically-inclined government, and made it an adjunct to his Nazi state. He entered into an alliance with the fascist government of Italy, and he tested out his new weapons by giving aid to the Spanish dictator, Francisco Franco, who

successfully overthrew the elected government by civil war. In 1939 he marched on Poland to inaugurate what he announced as a new era for Europe under the hegemony of the Third Reich, which should endure for a thousand years.

2. *Japan's bid for colonial power*

While Europe's Asian colonies were beginning to slip from their rulers' grasp, Japan projected a new Asian colonial empire under her rule. Her island homeland was small and her population large and growing. Her industries depended heavily on foreign trade for raw materials, fuel and other industrial supplies. A substantial part of her food supply was imported from abroad and she had to seek foreign markets. She looked to colonial development to meet her needs. The mainland of China offered many of the resources and markets which Japan required, if these could be brought under control and developed. The principal lack in this area was oil, and this seemed within reach on the islands of the Indonesian archipelago. The plan of Japan's imperialists was therefore to create a land empire to the north-west and an island empire to the south-east, and to organize the whole into an autarchic economy.

The first effective extensions of Japanese authority had been the fruits of her wars with China and Russia; from the former she had secured a food area, Formosa, and from the latter a region of potential industrial development, Korea. During the first world war she had forced her Twenty-One Demands on China to establish a paramount position in important areas of northern China and an attempted protectorate over the Chinese government.

In the decade following the war political leadership in Japan passed into the hands of a democratically inclined faction which acceded to pressures for withdrawal from China and for limitation of naval armaments. But when the world depression destroyed Japan's foreign markets and reduced her people to misery, the militarists, who had regained control, launched a series of moves designed to build Japan into a great Asian power. In 1931 Japan invaded Manchuria, set up the puppet state of Manchukuo and launched a vigorous programme of industrial development to supplement the resources of her crowded islands. In the following years she penetrated farther into China in a succession of aggressive moves and added other Pacific islands to those which she had inherited from Germany at the end of the war. Finally, in 1937 she launched a full-scale war against China which ultimately merged into the second world war.

3. *Growing importance of the United States of America*

The changed position of the United States in world politics was dramatized by her part in the peace negotiations at Versailles. Although Britain and France were represented at the peace conference by experienced statesmen who sometimes outmanœuvred the American president, it was President

Woodrow Wilson who was the principal arbiter of the destinies of the defeated nations. And it was not because she met opposition that the United States failed to follow through and to continue to exercise the political leadership that was hers; her own people were unwilling to assume that role. The American people were loath to have a position of leadership forced upon them in a world whose disorder only confirmed their traditional feeling that they wanted to be free of old-world conflicts. They had risen to the crisis of war but, this duty done, they were eager to return to their preoccupation with the permanent revolution in economic and social life which they were living out —to resume the domestic reforms which President Wilson on the eve of the war had named the 'new freedom', to exploit the new technology that offered a vision of release from back-breaking toil for farmers, workers and their wives and that was introducing the motor car, the radio and leisure into the life of the ordinary man, to return to what President Wilson's successor described as 'normalcy'. In this atmosphere the Senate of the United States turned back to the historic policy of non-entanglement and refused to ratify the treaties and to join the League of Nations of which the president of the United States had been the major architect.

It was only in the political sphere, however, that the United States withdrew from its position of pre-eminence. In the reconstruction of war-torn Europe and the settlement of reparations problems her leadership continued to be effective. No amount of political isolationism, moreover, could conceal the fact that New York had become a major financial centre. The principal European nations were indebted to the United States and the dollar largely replaced the pound sterling as international currency outside the British Commonwealth area. Financial pre-eminence was matched by an unprecedented increase in industrial potential. The United States became the leading industrial producer in the world to an extent that even Britain had never been before.

The revolutionary character of this transformation was not fully perceived, for American industry produced primarily for its own practically inexhaustible internal and hemispheric market while European nations retained a pre-eminent position in the markets of Asia and Africa. But the widening gap between Europe and America in productive efficiency and *per capita* income marked the real shift in the basis of power. The United States had grasped the potentialities of modern industry. When Europeans shuddered, as they often did publicly, at signs of the Americanization of Europe they were frequently reacting, at least in part, to the modernization of their own industrial society which they associated with the United States only because she had accepted the implications of industrialism more completely.

Though the new leadership of the United States was obscured in Europe by her act of self-restraint in the political sphere, in east Asia it was fully apparent. By her firm attitude toward the Japanese claim to control China during the war she had assumed a leadership and initiative which she did not

surrender thereafter. After the treaty of Versailles the United States stood forth clearly as the dominant foreign power in the Far East. She became distrustful of Japanese policy as Japan expanded to the island groups near the equator, occupied the Shantung peninsula of China and augmented her naval armaments. The Washington Naval Conference convened by President Harding in 1921 was a clear declaration of American leadership in the East. At the conference the United States secured the dissolution of the Anglo-Japanese alliance, the return of Shantung to China, and an agreement on naval limitation which held down the Japanese navy to three-fifths of either the British or the American and established naval parity between the United States and Britain, though the latter had always tried to keep her fleet at least as big as the sum of her two nearest rivals.

From the Washington conference on, America's authority in the Far East grew steadily, but it was only after 1931 when the Japanese forced the issue in Manchuria that the full nature of American leadership in east Asia became clear. The Japanese occupation of Manchuria led to the Stimson declaration that, in substance, the United States did not intend to recognize any infringement on the sovereignty or territorial integrity of China. Although ineffective at the time this amounted to a declaration against Japanese expansion. Thereafter the United States maintained a steady pressure against Japan by giving aid and assistance to China in her struggle, by working up an impressive solidarity at the League of Nations and in the world against the recognition of Manchukuo and by isolating Japan diplomatically until she finally sought allies in Germany and Italy. It was the Japanese reaction in the attack on Pearl Harbor in December 1941 which provided the occasion for the entry into the second world war of the United States with its vast industrial resources.[11]

4. *The emergence of the Soviet Union as a new power*

From the time of the October revolution the Soviet Union was a force to be reckoned with. Even at its lowest point, when torn by civil war and armed intervention and racked by famine and epidemic, its revolutionary appeal to the oppressed classes of Europe and peoples of Asia was a threat to the established order. The mere fact that the area from the east of Poland to the Pacific, from the Arctic to the borders of China, India, Persia and the Black Sea—the largest single and continuous land area in the world—came under a revolutionary régime was in itself of supreme importance.

From the time of its birth the European powers and the United States opposed the communist state, whose leaders professed a dynamic theory which they claimed to be the absolute political truth of the future, valid throughout the world. But in 1917 the powers were still locked in a life and death struggle, and when they were free to intervene more actively after the end of the war their people were tired of war and weary of superhuman

efforts to achieve victory. Their armed intervention met resistance and everywhere ended in disaster, though at one time effective Soviet authority was confined to a comparatively small area in the region of Moscow.

When the dust of intervention cleared two things stood out plainly. In spite of eruptions in parts of Germany and a short-lived communist régime in Hungary, which were put down quickly and violently, there was no immediate likelihood that the proletariat of the world would follow in the Russian footsteps. The prospects of an immediate world revolution had become dim.

At the same time it became equally clear that whether the rest of the world liked it or not the Soviet power had come to stay. The Treaty of Rapallo concluded in 1922 between Germany and the Soviets was an unmistakable reminder that, though weakened by civil war, foreign intervention and internal economic crisis, Russia was a factor which could not be ignored in the world. However much the European nations might be repelled by the liquidation of capitalists, landowners and well-to-do peasants (*kulaks*) on economic or political grounds, attracted by the efforts to build a classless society on a socialist basis, worried by the possible contagion of ideas to their own people, or fearful of the revival of Russia's historic territorial aspirations with a new dynamic force, they could not fail to take her presence into account.

The political recovery of the Soviet area reduced to lesser proportions the smaller units in eastern Europe out of which Marshal Pilsudski of Poland hoped to build an Intermediate European Federation. As a result of the leadership which the Russian communists enjoyed as the first in world history to establish the dictatorship of the proletariat, the Communist party of the USSR acted as a guide to the communist parties throughout the world which were united in the Comintern, or Third International.

The economic revival of the USSR after an initial period of unexampled misery had equally far-reaching results. In the face of an economic boycott by the west European nations and the United States the communist leaders had been forced to adopt a policy of heavy temporary sacrifices in order to convert Russia into an industrialized nation. In 1928 they stepped up the pace of industrialization with the inauguration of the first five-year plan. By the eve of the second world war Russia's production of steel had become as great as that of Germany; though her economy had still great gaps, it was already apparent that a powerful industrial state had risen from the ashes of tsarist Russia. After the great depression the prestige of the Soviet Union markedly increased, for its economy was untouched by the crisis and its industrial development went on while in other countries men and machines stood idle.

With the emergence of Hitler and the revival of German military power the relation of the Soviet Union with the European states underwent a change. Throughout the 1920s the Soviet position was one of isolation. Although failure of the intervention in 1922 removed for the time being the immediate threat of direct military aggression, and although the faction of the Communist party which advocated the pursuit of revolutionary socialism in one

country triumphed over the supporters of world revolution, the Soviet Union viewed the capitalist countries as essentially hostile neighbours.

From 1929 on, especially after 1931, the Soviet Union began to negotiate non-aggression agreements with her immediate neighbours, Poland, Lithuania and other states on her western borders. In 1932 she entered into a non-aggression pact with France and in the following year signed an agreement defining aggression with the countries to the south, Afghanistan, Persia, Turkey. The Soviet leaders were aware of the great implications of the revival of reaction in Germany, of Germany's desire for expansion to the east, of Rosenberg's theories about the right of Germany to living space in the Ukraine and elsewhere, and of the doctrine of the German geopolitical school whose unconcealed objective was to control the heartland—the vital plains of European Russia. They were also aware that there were powerful groups in western Europe and the United States as well as in Germany who saw in the revival of German power a counterweight to Russia and even hoped that Germany might be the means of ridding the world of the communist threat.

The Soviet riposte to the possibility of Germany being used as the spear-head of western reaction was open advocacy of collective security. In 1934 she was invited to join the League of Nations, and the world began to witness the unfamiliar spectacle of the Soviets as the champions of peaceful settlement of disputes and the literal observance of treaties. In every matter that came before the League—Japanese action in Manchuria, Italian aggression in Ethiopia and German action in different regions of Europe—the Soviet representative became the most vigorous pleader for collective action. The preview of another world war provided by the Spanish civil conflict was everywhere recognized as of supreme importance. Russia saw it as the prelude to a systematic campaign by the fascist powers directed against her, and sent her volunteers and military strategists to aid and lead the Spanish republican forces.

Until the failure of collective security evidenced by the Munich pact in September 1938, the USSR expressed its readiness to join with western European nations against Germany. After the Munich pact, however, the Soviet Union doubted the determination of Britain and France to resist Germany and in the following year entered into a non-aggression pact with Hitler. But when the collapse of France released the German forces for other operations the Russo-German pact became a scrap of paper as Hitler's armies swept eastward over the Russian land. The strength with which the Soviet armies and people stood against the German might and reconstructed their country after untold devastation bore witness to the success with which a largely agrarian, feudal society had been remade into one of the two greatest modern industrial states.

5. *Rising nationalism against colonial powers*

In the heat of the first world war the powers made promises and held out hopes to subject peoples—their own and those of their enemies—which they

were reluctant to make good when they no longer urgently needed these people's support. But the impetus to nationalism in Asia and in the Middle East was too great to be checked. Nationalist movements were ready to take advantage of signs of weakness among the colonial powers and of their preoccupation with problems of economic depression. The Soviet Union afforded a constant example of the possibility of consciously remaking society and it offered direct assistance to the 'toilers of Asia'.

During the war, the Arab peoples within the Ottoman empire were encouraged by the western allies to fight against their Turkish rulers, and they expected that independence would be their reward. Defeat of the Turks brought dismemberment to the Ottoman empire. But instead of achieving independence the Arabs found themselves in varying degrees under the protection or authority of Britain and France. British plans called for direct rule in the valley of the Euphrates, control of the Arabian peninsula and much of the Fertile Crescent through Arab leaders whom she supported as her allies, a protectorate in Egypt, a mandate over Palestine and a working agreement with the sultan of Turkey. The area was crucial, for it had been found to be immensely rich in oil, and oil was becoming the lifeblood of industrial countries as they entered the motor age. The British fleet was being converted from coal to oil and thus could no longer be supplied by home resources.

British hopes of easy dominance in the Middle East were, however, short lived. Turkish nationalists under the leadership of Mustapha Kemal fought for the complete independence of the modern national state which they organized in the Turkish heartland of Anatolia, and achieved their goal by 1923. The rival claims of France in the Fertile Crescent resulted in the driving out of Britain's Arab nominees and the establishment of a French mandate over Syria and Lebanon. The monarchy set up in Iraq pressed for independence. In the Arabian peninsula, King Hussein of Mecca who had originally been supported by the British was driven out of his kingdom by a rival dynastic leader, Abdul Aziz ibn Saud. The Egyptian nationalist movement won its first victory against Britain and gained partial independence for Egypt, a lesson which was not lost on other nationalist movements in the area. Britain's own commitment to the idea of a Jewish homeland undermined her relations with her Arab allies.

French authority in the Middle East encountered even more intense resistance than did the British. Though France sent a series of top military leaders as high commissioners for Syria, she faced open rebellion, and the area under her mandate was in effect held under military occupation. When the French authorities in 1925 went to the extreme of shelling the city of Damascus it was apparent that French persistence was being met by intense and determined Arab nationalist feeling.

Iran and Afghanistan, too, shared the prevailing nationalism in the Middle East. Since 1907 Persia had been divided by Anglo-Russian agreement into two spheres of influence and during the war, in spite of her neutrality, British

forces had occupied parts of Persian territory as a step in fighting the Turks and later the Bolsheviks. The Russians in the first flush of the revolution renounced their claims under the Anglo-Russian agreement, and the movement for the recovery of Persian sovereignty was therefore directed mainly against the British. In 1921 Reza Khan seized control and in 1925 deposed the shah, assumed the crown and pushed forward a scheme of modernization. The dominant British influence in the south, exercised largely through the Anglo-Persian Oil Company, was the target of his attack; in 1932 the oil concessions were cancelled, to be replaced by an agreement more advantageous to the Persians. Afghanistan under King Amanullah in 1919 threw off the limitations which Britain had imposed on Afghan sovereignty and was soon afterwards recognized as an independent state.

Thus everywhere in the Middle East nationalism was rising and the European powers, though seeking to assert their influence and to gain new ground, were beginning to be forced to retreat.

The greatest of the colonial areas, India and Burma, emerged from the war with a form of partial self-government which marked a definite breach in the citadel of imperial authority. Under a system known as dyarchy power over education, health, local government and similar matters at the provincial level was transferred to elected representatives, while finance and the maintenance of law, order and defence were reserved to the central colonial government. In the central government half the members of the cabinet were nominated from among Indians and a majority of the legislature was subject to election on a restricted franchise.

The nationalist movement which had grown greatly during the war was not, however, content with this limited arrangement and pressed for immediate self-government. Under Mahatma Gandhi's leadership, the Indian National Congress adopted a dynamic, revolutionary programme based on non-cooperation with the British, a boycott of British goods and organization of the people to prepare them for independence. In this he had the support of a considerable section of the Muslims under the banner of the Khilafat movement.

From 1920 on, the drive for independence never slackened, and it was clear that India was unlikely to remain long under British rule. Britain sought to limit or delay independence by building up the princely states of India in direct relationship with the British Crown and by acceding to the separatist claims of the Indian Muslims. The first of these efforts to prevent the unity of the Indian people was unsuccessful. At the Round Table Conference summoned in London in 1930 in an attempt to reach a negotiated settlement, the princes, whose territories covered over two-fifths of the land area, offered to federate with the rest of India. As far as the Muslims were concerned, they ultimately demanded partition; but they were no more willing than the rest of the people of the sub-continent to remain under British rule. In the negotiations for independence they worked successfully for the establishment

of a separate state, Pakistan, out of the provinces in which they constituted a majority.

China offers perhaps the best evidence of the breakdown of European supremacy following the first world war. Refusal of the Chinese delegates to sign the Versailles Treaty, and student demonstrations in Peking in 1919 against the decision of the Allies to permit Japan to occupy Shantung, were portents. At the Washington Conference in 1921 China's claims for equality were conceded in principle even at a time when that country had no effective government. Her representative's demand for tariff autonomy was not opposed by any power and the states concerned agreed under certain conditions to abandon foreign postal privileges not later than January 1923.

During the period between the students' movement in 1919 and the establishment of the national government in 1927 by Sun Yat-sen's successor, Chiang Kai-shek, the most remarkable feature of the Far Eastern situation was the changed behaviour of the western nations in the face of Chinese anti-foreign agitation. When for example the Shanghai police fired on a student demonstration on May 30, 1925, agitation spread to other cities from this great international centre where the Europeans still ruled; in Canton British troops resorted to firing. The Chinese retaliated by an effective blockade of Hong Kong and a boycott of British goods which they maintained for over a year. In the pattern of the relationships which had existed before the war such a blockade would have been answered by gunboats and further concessions would have been exacted as compensation. In 1925 however, though China could not have offered military resistance, Britain did not feel that she could use force and she even took part in a conference in Peking to devise measures to restore China's tariff autonomy at the very time when these hostile demonstrations were going on.

In south-east Asia Indonesia had remained comparatively unaffected by the war, for the Netherlands had not been a participant; but there too nationalism began to be a force in the following period. The Dutch government faced its first serious opposition in the nationalist rebellion of 1926. French authority in Indo-China was also challenged as communism began to spread. But in both these areas movements for independence did not gather effective momentum until the general collapse of colonial authority in the second world war.

IV. THE SECOND WORLD WAR AND AFTER: NATIONS AND PEOPLES IN A NEW WORLD

The second world war brought into full being the new world pattern which had been building up from the beginning of the century. The pattern had taken shape in the first world war, and its outlines had come to be recognized as economic depression effectively closed the road back, ambitious dictators challenged the old order, the USA and USSR revealed their mounting

strength, and the ferment of self-determination marked for early defeat the theory as well as the practice of colonialism.

It was the efforts of dictators to remake and dominate the world—Hitler in Europe and the Japanese militarists in Asia—that precipitated the world conflict. Hitler, pursuing the bold dream of European unity under the Nazi swastika, was prepared to use any measures, at home or abroad, to achieve his goal. Encouraged by the success of his piecemeal measures—in the Rhineland, in Austria, in Czechoslovakia—he believed that he would meet little opposition, and was confident that the new, swift weapons of offence—tanks and planes—would bring quick victory to his arms. With fascist Italy as his ally and communist Russia neutralized for the time being by the Russo-German pact, he took the great gamble of plunging Europe into war.

In the Pacific Japan was prepared to venture with equal boldness. Her daring and successful surprise attack against the United States fleet at Pearl Harbor and US installations in the Philippines on December 7/8, 1941, instantly brought the United States into the war, made the Japanese war in China part of the world war and converted the European war into a global conflict. In a few swift weeks Japan overran the French, British and Dutch possessions in south-east Asia, the Indonesian archipelago and the islands of the Pacific. Announcing her objective as the creation of a Greater East Asia Co-Prosperity Sphere, she organized the oil and other resources of these areas for her defence. In the process she released the colonial peoples from their European rulers and, though she substituted her own authority, destroyed the institutions through which former colonial suzerainty had been exercised and demonstrated to the subject peoples the impotence of those who had been their masters.

The second world war differed from the first in that it was a war of movement; the weapons of offence, especially the tremendous striking power of aircraft, had outstripped those of defence to make warfare once again a matter of attack and counter-attack. Even more than in the earlier conflict it was industrial potential that ultimately won through, as the unprecedented output of American industry poured on to every battlefield, as British production continued in spite of air attacks and as Russian factories beyond the Urals replaced those lost in her western industrial belt.

Far more than before, too, it was the civilian population which bore the brunt; among the many millions of Europeans young and old who perished in the war, scarcely more than a third were military personnel. The high civilian toll reflected not only the character of total war but the ideological basis of the struggle, for, as the resistance and partisan movements throughout Europe bore witness, the war became to a considerable extent a civil war; in addition, the civilian casualties in Europe included the Jews who were marked for extermination.

Most important of all, science changed the scale and manner of warfare; the culminating scientific achievement of the atom bomb, dropped on Hiro-

shima to wipe out in a single blast some 100,000 inhabitants, made it clear that science had carried the art of destruction to a new level, as radically different from what mankind had known before as had been the change wrought by the introduction of gunpowder in an earlier century. Henceforth the shape of world power was inseparable from the implications of the atomic—and soon the even more terrible hydrogen—bomb, which cast its fearful, radioactive shadow over the entire earth.

The world emerged from the second world war with two great powers towering above the rest, the USA and the USSR. With her homeland undamaged and her industrial productivity enormously increased, the United States was the major source of wealth for reconstruction, as she had been for the supplying of war material. Her world industrial leadership may be seen in the fact that five years after the war, when the European economies had largely recovered, she was producing 43 per cent of the world's iron ore and 45 per cent of its crude steel, 60 per cent of its locomotives and 74 per cent of its motor vehicles, 64 per cent of its radio receivers, 50 per cent of its rayon and 86 per cent of its other synthetic fibres.

In a move to rebuild the shattered economies of Europe and to restore the productive potential of her allies, the United States made available large amounts of money, surplus war material and technical aid, carrying over into peacetime the same concept of partnership in effort which had been the basis of the wartime programme known as lend-lease. In addition, as the sole occupying power in Japan and one of the four occupying powers in Germany, she poured money and effort into the rehabilitation of her former enemies, and stimulated a spectacular revival of their economies. When the United Nations and its specialized agencies were created the United States became the largest contributor, supplying from a third to a half of the budgets of these bodies. Under what was first known as the Point Four Program by virtue of the manner in which the proposal had been presented by President Harry Truman in 1948, she offered substantial technical aid to economically underdeveloped countries in their efforts to modernize their societies and made it possible for numbers of leaders, specialists, and students to visit or study in the United States.

Yet in spite of these unprecedented world commitments the American people retained some of their historic reluctance to become involved in world affairs and to assume the responsibilities of power which circumstances had thrust upon them. They met the demands of war and reconstruction, as they had those of the first world war, in terms of a crisis. They could not again withdraw, as they had when they refused to join the League of Nations, nor did they wish to do so. But they were still mainly preoccupied with opportunities at home, and after more than a decade in a paramount position the American people had yet to develop a clear and positive attitude toward the exercise of world power. Meantime the impact of American industry and private foreign investment was felt in many parts of the world.

Within months of the close of the war it became clear that the western allies and Russia, which had fought side by side after Hitler invaded the Soviet Union, were working at cross-purposes when it came to organizing the peace. The zones into which Germany had been divided for purposes of administration by the occupying powers became a division into two separate entities, as Russia supported the establishment of a communist-led state in its zone to the east, while the areas occupied by the United States, Britain and France in the west formed a federal republic, with West Berlin left as an island within East Germany. In one after another of the countries immediately bordering on the Soviet Union in east Europe, which had been liberated from the Nazis with the aid of the Red army, a coalition government led by its communist element made its way to power and by 1948 all had set up régimes of 'people's democracies', with such support from the Soviet régime or from the Red army as the situation in each case required.

In these circumstances a new contest developed between the Atlantic community, consisting of western Europe and America, and the communist bloc, composed of Russia and the east European states. The contest became global when the Communist party in China gained power in 1949 and the Chinese People's Republic joined the communist camp.

The policy of containing communism led the members of the Atlantic community to support the non-communist governments of countries on the periphery of the communist orbit, notably Greece and Turkey; to transport supplies to West Berlin by airlift when access by land was cut off; to form an Atlantic alliance with international forces under unified command; and to create looser alliances in the Pacific and the Middle East.

The policy brought open conflict in Korea and Indo-China. In 1950 the majority of the non-communist countries, following the initiative of the United States, joined in military resistance to prevent the incorporation of South Korea into communist North Korea which had been allocated to Russian administration at the close of the war and had been organized as a communist-led state in a manner similar to East Germany. The Security Council of the United Nations, acting in the absence of the USSR which boycotted the session, declared North Korea an aggressor; for the first time in history troops of many nations fought under the flag of an international organization, the flag of the United Nations. The conflict was held to a stalemate by the entrance of the Chinese People's Republic on the side of North Korea after the battle had reached the frontier of China itself. This act of support for a country which had been declared an aggressor was the main stated reason for excluding the Chinese People's Republic from membership in the United Nations during the following years. In Indo-China resistance to the spread of communism became intertwined with the long, unsuccessful struggle of France to retain her hold on the area and led to the division of the territory in 1954 into a northern region under communist control and the states of Vietnam, Laos and Cambodia under non-communist leadership.

In both Europe and Asia, it was the resources of the United States which furnished a large part of the military strength deployed around the periphery of the communist-dominated area, in the form of American forces stationed in Europe, north Africa, the Middle East, the Arctic, the Pacific and various points in the western hemisphere, and in the form of military aid to other countries. In the 1950s there were hundreds of American military installations, large and small, outside the continental United States which had been established by agreement with host countries for common defence or on Pacific islands formerly held by Japan which had become United Nations trust territories under United States administration.

In contrast to the United States, whose homeland had remained undamaged, the USSR suffered war devastation even greater than that of defeated Germany, for the fighting which had raged over her western area had destroyed her cities, levelled an estimated third of all her urban homes, ruined factories and laid waste the land. She owed her survival and ability to make a rapid recovery in part to the foresight of her leaders who, expecting war in the west, had established much of her heavy industry east of the Urals, and to the transfer of activity to that region from the west during the war.

Yet in spite of wartime destruction she not only regained her strength and renewed her advance in production but, within less than five years, she ceased to be the only communist state in a non-communist world and became the centre of a communist group extending from the Pacific to Berlin and from Siberia to Indo-China. With the accession to communism of the countries of east Europe and the Chinese People's Republic, what had been but a single instance of a communist state became, within a short period, a competitive world system controlling a third of the world's population and equipped with the latest technology in science, industry and armament.

In the middle years of the twentieth century there were thus two worlds, one calling itself the 'free world', the other the communist world. But each believed only in one world—its own. To the free world, that of the communists loomed as a threat to its power, its institutions and its values. To the communist world, its doctrine and its system alone had universal validity.

The policy of each was to stand firm against the expansion of the other and to seek means of extending its system. The Kremlin tolerated no deviation from the general party line and repressed without hesitation signs of defection among its east European associates, notably the 1956 revolt in Hungary, put down as a counter-revolutionary movement with the aid of Soviet troops.[12] Yugoslavia, however, maintained a national communist régime isolated from the Soviet-led communist group. Outside the communist area the Communist party of the Soviet Union worked to strengthen its ties with the communist parties in other countries and supported national liberation movements. The free world, in turn, looked for chinks in what the British wartime leader, Sir Winston Churchill, dubbed the 'iron curtain', through which to reach and appeal to the people under communist control, and they tightened their own

security systems in various ways against communists at home, making the Communist party illegal, raising bars to immigration and travel, excluding known or suspected communists from certain positions, especially those of responsibility and trust, and otherwise restricting democratic freedoms. Both groups set up military–political blocs and enhanced their military potential.

With the world thus divided, and with the new and terrible weapons making it plain that another full-scale war could mean hardly less than suicide for humanity, the cold war—as the relations between the two worlds in the 1950s came to be called—took the form of the building up on either side of deterrent forces of nuclear arms, borne first by ever-swifter, jet-propelled planes travelling faster than the speed of sound, then by guided missiles traversing outer space.

The contest took the form, too, of advances in science, technology and production. The USSR declared her intention to challenge the leadership of the United States in industrial production, and sought to accelerate her rate of industrial expansion with each five-year plan. Her notable scientific progress was grounded in the distinguished Russian scientific achievements of pre-Soviet days, it was stimulated from the beginning of the Soviet régime by a policy of staking national progress on scientific advance, and it was supported by a vigorous programme of mass education in which scientific subjects played a central role. When the USSR succeeded in placing the first earth satellite in outer space in October 1957, the world knew that the leading nation of the communist world was in the front rank in the vital field of scientific advance on which modern society had come more and more to depend.

While the two major powers and their associated worlds pursued their competitive courses, the new nations liberated from colonial rule struggled to establish stable political institutions and to find effective means to develop their economies and raise the level of living of their people. They wanted no part in the cold war and resisted the efforts of both protagonists to make them take sides. On the one hand their governments and other institutions were generally patterned on those of Europe or the United States and it was in terms of European principles of freedom and democracy that they had fought for their liberation. On the other hand they saw in the Soviet Union a country which had used economic planning and the central direction of national effort to achieve rapid industrialization—the goal which they ardently sought—and they saw the largest of the economically underdeveloped areas, China, choosing the same route.

It was clear, however, that the issue in the world contest between rival systems would inevitably depend to a major degree on the fate of these neutral uncommitted nations of the Indian sub-continent, south-east Asia, the Middle East and Africa. Both dominant groups therefore sought to draw them to their side, by strategic appeals and by offers of economic and technical aid. And within each new country rival elements attempted to push their governments in one direction or another. At times such conflicts impeded the difficult, central task faced by all these countries—that of converting ancient,

technically primitive, often densely populated agrarian societies into modern, prosperous economies in which their people could aspire to standards of living more nearly approaching those of the technically developed countries of the world.

The mounting importance of this part of the world was reflected in the emergence of an Afro-Asian bloc. In 1955 twenty-three Asian and six African nations, from Japan to Liberia, assembled at Bandung, Indonesia, in an historic conference of Afro-Asian nations. At the Bandung conference the assembled nations declared, in essence: 'Here we are, The time has passed when the world can act as though we did not exist'.

Even at the close of the second world war it was not immediately apparent how deeply tropical Africa had already been stirred by the nationalism that was abroad in Asia and the Middle East, and by the evident decline of the imperial powers. To be sure, the policy of reserving to white settlers the best land in the highlands of Kenya had been challenged before the war by a British-educated African leader, Jomo Kenyatta, and Britain's announced policy in West Africa during the war was to prepare for ultimate independence. But few people were prepared for the swiftness with which a vague hope was converted into practical, determined steps toward independence in one African area after another.

In 1956 the Anglo-Egyptian Sudan voted for independence rather than either union with Egypt or a continuing tie with Britain. The Gold Coast chose the name of an ancient African kingdom, Ghana, when it celebrated its independence from Britain in 1957. By then other British African areas such as Nigeria and Uganda were on the way to independence. Where the population included European settlers, as in Kenya, the Central African Federation and Tanganyika, the question was not whether these areas would become independent but what would be the relations among the European, Indian and African elements when independence was secured.

France hoped to retain her Sahara empire by her traditional method of assimilating as Frenchmen the educated African *élite* and incorporating overseas territories into the French body politic; but already in 1946 she had admitted the principle of self-government, by 1957 she had granted her West and Central African territories a measure of autonomy, and in 1958 Guinea became the first of these territories to withdraw from the French community and set itself up as an independent African state. The long struggle over Algeria threatened the stability of France itself, as the French minority in Algeria fought to keep the country a part of France while the Muslim majority waged a war of liberation. Belgium hoped to find some formula for a partnership which would keep the immensely rich Congo tied into the Belgian economy and the Belgian state, but she could not resist mounting restiveness and yielded to the demand for independence. Portugal, making no concessions to the idea of African separatism, virtually sealed the borders of her African territories in the effort to exclude contamination from outside. The full effects

of the awakening of Africa had only begun to be seen at mid-century, but that this awakening was a major new political reality of world importance none could overlook or deny.

Another major area whose potential importance had only begun to be recognized internationally was Latin America. Although the republics of South and Central America had enjoyed independence since the early nineteenth century, most had continued to be predominantly agrarian with semi-feudal economies; in some, large sections of the indigenous Indian population had remained outside the main stream of national economic and political life. They thus shared many of the problems encountered by other economically underdeveloped countries in their efforts to overcome illiteracy and poverty and to achieve balanced economic development. At the middle of the century Latin America, with the most rapidly growing population of any region, with a wealth of resources to be developed and lands to be settled and with an aroused determination to achieve greater economic independence and progress, appeared likely to become an increasingly important factor in world affairs.

Meanwhile the countries of Europe in the decade after the second world war faced the need to find a new basis for effective survival, stability, security and prestige. Though western Europe had lost much of its ability to exploit vast resources overseas, it still constituted an area of some 300,000,000 people with the highest level of education and technical skill of any comparable body in the world, with many of the resources on which to base a strong economy and with a potential market capable of sustaining highly productive industry as did the home market in the United States.

A first step toward European economic integration was the creation of the European Coal and Steel Community shortly after the war. Since the crucial problem of Europe as a self-based economy was fuel, the possibility of developing atomic energy as a source of power offered an attractive alternative to continued dependence on oil from the politically uncertain Middle East. In 1957 six European nations—France, West Germany, Italy, Belgium, Netherlands, Luxembourg—formed a common organization, Euratom, to exploit this new resource. At the same time they took steps to open their markets to each other's products and agreed to develop a common European market in the heart of western Europe with which other European countries might later become allied.

These steps marked the beginnings of a new kind of Europe, no longer the Europe of competing colonial powers but a technically advanced, interrelated entity within the modern world. The growth and vigour of the European economies in the 1950s was evidence of their continuing vitality and new potentiality.

Though the world at mid-century was sharply divided, this very division created conditions which required organization of the world community. The creation of the United Nations as the second world war was coming to a close

expressed the urgent sense, far more intense than it had been when the League of Nations was set up after the first world war, that international organization was indispensable to human survival.

In the presence of competing world systems the United Nations and its specialized agencies afforded a means through which the members of both groups could communicate with each other and could work together on matters of common concern which transcended their differences, although the absence of the world's most populous nation, the Chinese People's Republic, impaired the universality of these agencies. Moreover, the United Nations was the principal channel through which the new nations made their world presence felt. Although the former great powers continued through the 1950s to dominate the United Nations Security Council, the Assembly where each nation had an equal voice came more and more to take on the tone of the new nations as, one after another, they joined its ranks.

And it required only a glance at the faces of the Assembly delegates to make it clear that this was no longer a white man's world. For the shift in world power that had taken place in half a century was not only from the old, imperial European core to the new leaders of the communist and non-communist worlds. Less pronounced but no less real was the trend from the dominance of the white to the equality of non-white peoples. In a world where populations that classified themselves as white numbered no more than perhaps a quarter of the whole, and where the equality of nations and peoples was coming to be accepted in principle, the darker peoples could not fail to play a growing role. Though racial prejudice was far from dead and determined groups fought to maintain white supremacy within their own societies —in South Africa, in Kenya, in southern parts of the United States—a white skin had ceased to be the badge of privilege or superiority which it had been in the world which Rudyard Kipling had described.

International co-operation, moreover, was playing a part in the efforts of newly developing nations to gain some of the scientific and technical knowledge which had remade the industrialized segments of the world. In the new structure of power, these peoples had the conscience and self-interest of mankind on their side in their efforts to rise. This provided a new dynamic for world relationships and an imperative which gave international organization a practical as well as a political role.[13, 14]

NOTES TO CHAPTER I

1. Professor E. N. Anderson suggests the following discussions of historical writing for perspective on the method and approach of this volume:
   Raymond Aron, *The Dawn of Universal History* (London, 1961).
   Geoffrey Barraclough, *History in a Changing World* (Norman, University of Oklahoma Press, 1956).

Isaiah Berlin, *Historical Inevitability* (New York, Oxford University Press, 1954).
Herbert Butterfield, *Christianity and History* (London, 1943).
Herbert Butterfield, *History and Human Relations* (London, 1951).
R. G. Collingwood, *The Idea of History* (New York, Oxford University Press, 1946).
H. P. R. Finberg (ed.), *Approaches to History* (London, 1962).
Romano Guardini, *The End of the Modern World* (New York, 1956).
H. Stuart Hughes, *Consciousness and Society* (New York, 1958).
Jacques Maritain, *On the Philosophy of History* (New York, 1957).
Hans Meyerhoff (ed.), *The Philosophy of History in Our Time. An Anthology* (New York, 1959).
L. B. Namier, *Avenues of History* (London, 1952).
Karl Popper, *The Poverty of Historicism* (Boston, 1958).
Social Science Research Council, *Theory and Practice in Historical Study*. Bulletin 54 (New York, 1946).
Social Science Research Council, *The Social Sciences in Historical Study*. Bulletin 64 (New York, 1954).
Fritz Stern (ed.), *The Varieties of History* (New York, Meridian, 1956).
Caroline F. Ware (ed.), *The Cultural Approach to History* (New York, Columbia University Press, 1940).

2. Professor C. K. Zurayk comments: 'There is a constant mention of the "Communist and non-Communist worlds". It seems to me rather unfortunate that we have to describe the Western World negatively and to place it after the communist world. I realize the great difficulty of choosing an appropriate positive term, such as Free, or Democratic, etc. Although "Western" is open to many objections, it is still, I believe, better than a negative term.' Professor Wilhelm Röpke writes: 'When the authors say that the world was sharply divided politically between the Communist and the non-Communist groups, and divided economically between industrially developed and "underdeveloped" segments, the picture they give cannot be more wrong. It obscures the fact that the division between the communist and the non-communist world is not only political, but ethico-cultural and economic and in all these aspects the most profound that could be imagined. It can in no way be compared with the dividing lines within the free world itself.'

3. *The Author–Editors call attention to the fact that the term 'Western' is used throughout the text to refer to occidental culture and is not used in a political sense.*

4. Professor M. S. Ivanov, Professor A. F. Miller, and other personalities who examined this question, stress that it was above all the Russian revolution of 1905–7 that exercised an effective influence upon the development of the national-liberation movement of the peoples of the East in 1905–12 (the so-called 'awakening of Asia'). Thus V. Chirol, an English writer who was at that time *Times* correspondent in India, described the impact of the 1905 events on India in the following way: 'But there were Indians to whom it meant even more than a mere humbling of a great European power by an Asiatic race. It meant also a mighty blow to the autocratic system in Russia and to that system the Indian extremists never tired of likening a system of Indian Government concentrated in the hands of an all-powerful bureaucracy. British officialdom in India was denounced as the counterpart of the *chinovniks* who ruled and ruined Russia in the name of the Tsar, and to be fought if necessary with the same weapons which the Russian revolutionists were learning effectively to employ' (V. Chirol, *India*, London, 1926, p. 114.).

The Indian democrats who supported Tilak—a leading figure in the Indian liberation movement—published clandestinely a number of pamphlets in which they brought to the attention of the public the libertarian ideas of the Russian revolution of 1905–7 and the methods of struggle employed by the Russian revolutionaries. (See *Sedition Committee Report*, Government of India, Home Dept., Calcutta, 1918, pp. 42–4.)

E. G. Browne, an English author, cites in his work a letter from Teheran written by an eye-witness of the events that inaugurated the revolution in Persia: 'The Russian revolution has had a most astounding effect here. Events in Russia have been watched with great attention, and a new spirit would seem to have come over the people' (E. G. Browne, *The Persian Revolution of 1905–9*, Cambridge, 1910, p. 120).

One of the founders of the first Young Turk committee, 'Unity and Progress', Dr. Abdullah Djevded, wrote as follows in an appeal entitled *To My Turkish Compatriots*, despatched from Geneva early in 1907: 'To the entire oppressed population, Moslem and non-Moslem—unite! Poor and rich, weak and strong, women and men, young and old—unite! Look at Russia, look at Persia. . . .' The Young Turk newspaper *Türk*, published in Cairo, appealed to its readers 'to take as your example the magnificent ideas of the Russian revolution' (No. 118, June 1, 1906).

The liberation ideas of the Russian revolution had a great impact on the programme of Covenant Society (T'ung-meng Hui), the Chinese revolutionary organization founded in 1905 by Sun Yat-sen. Its theoretical organ, the journal *Minpao*, established in Tokyo in October 1905, printed in each issue long articles about the Russian revolution, the situation in Russia, and the history of the Russian revolutionary movement. In a number of these articles reference was made to the significance of the revolutionary events in Russia for China (See 'Democracy and the Perspectives of Revolution in China', No. 4, 1905; 'Salvation from Inexorable Ruin', Nos. 18, 19, 20, 1905; 'The Revolutionary Ideology', No. 25, 1905, and others).

5. Professor L. I. Zubok stresses that the Spanish-American War of 1898, which led to the Philippines, Cuba, Puerto Rico and Guam coming under American control (*Foreign Relations of the United States for 1898*, p. 940) inaugurated an era of imperialist wars, i.e. wars for the re-division of a partitioned world. The war showed that the most powerful capitalists in the United States were no longer content with the internal market alone, and set themselves the task of capturing markets in the world at large. From this time onwards expansionist theories came to exercise an ever greater influence upon the orientation of US foreign policy. The late Charles Beard, the American historian, refers to Admiral Mahan, President Theodore Roosevelt and Senators Henry Cabot Lodge and Albert Beveridge as the four 'wildest agitators' for an expansionist policy by the United States in the 1890's (C. Beard, *Giddy Minds and Foreign Quarrels: an Estimate of American Foreign Policy*, New York, 1939, p. 16).

It was at this time that the United States set out to capture the enormous Chinese market. But since China was already partitioned into 'spheres of influence' by the other powers, the United States enunciated the doctrine of 'open doors and equal opportunities', which enabled its goods to penetrate into these 'spheres of influence' and the Chinese territories leased to other powers. The annual account of the Bureau of Foreign Trade of the State Department for the fiscal year 1896–7 already contains the statement that the provision of equal opportunities in China 'will undoubtedly bring tremendous profits to United States industrialists, in view of the demand for provisions and goods of various kinds which they will be able to satisfy' (A. W. Griswold, *The Far Eastern Policy of the United States*, New York, 1938, pp. 56–7).

The principle of the 'open door' was put forward in identical notes despatched on September 6, 1899, by US Secretary of State, John Hay, to London, Berlin and St. Petersburg (see McMurray, *Treaties and Agreements with and concerning China*, New York, 1921, Vol. I, pp. 221–35).

Professor Zubok's point of view is endorsed by Academician D. Kosev who considers that the authors' attempt to portray the war between the United States and Spain in 1898 as a just war is a failure. This war bore an imperialistic character for both parties. As a result of the war the United States became a colonialist power, through its seizure of the Philippines.

Professor László Zsigmond believes that the facts do not bear out the view that the United States had no colonial ambitions, and that the Philippines and Puerto Rico became subject to the United States only as a result of the chain of circumstances. He notes further that the authors do not take account of the difference between the interests of American finance capital and those of the American people.

6. Doctor of Historical Sciences N. N. Yakovlev notes that the principle of the self-determination of peoples was advanced for the first time in the 'Declaration of the Rights of the Peoples of Russia', published on November 15, 1917, and also in the address 'To All Toiling Moslems in Russia and the East', signed by Lenin (December 3, 1917). So far as the declaration of W. Wilson is concerned, which was published on January 8, 1918, this was largely a propagandist document. The author himself found

it necessary to limit his promised 'basic principles' by sanctioning an accompanying official commentary. On the eve of the Paris Peace Conference, T. Roosevelt, giving expression to the majority view in Congress, emphasized that neither Wilson's fourteen points, with their four conditions and five appendices, nor any other of his statements any longer reflected the intentions of the United States. (See *Documents of American History*, ed. by H. Commager, New York, 1945, p. 331.) Of Wilson's twenty-three conditions (including addenda), only four were incorporated into the peace treaties with a measure of accuracy. Senator H. C. Lodge, dealing with the fact that the 'Fourteen Points' programme had been buried at Paris, wrote that the first point, about the elimination of secret negotiation, was infringed at Versailles; the principle of freedom of the seas (point two) was also discarded—this principle could not be carried through on account of British resistance. Point Three, in Lodge's opinion, was never seriously considered by anyone. Point Four 'related to a reduction of armaments. Nothing was done about that in the Treaty of Versailles, except the disarmament of Germany. . . . The League has since then done nothing about it. . . . 'The fifth point related to the adjustment of colonial claims, which seem to have been settled by the victorious Allied Powers taking all the colonial possessions of Germany everywhere. 'Point six related to the evacuation of Russian territory, and that of course was not dealt with at all accord- to the methods set forth by Mr Wilson, but was more or less temporarily and violently disposed of in the process of events which could not have been foreseen at that time. . . . (H. C. Lodge, *The Senate and the League of Nations*, New York and London, 1925, pp. 92–4).

7. Professor E. N. Anderson notes that the subject of decay in Europe has been discussed at length in both popular and scholarly writings, not merely during the interwar years, to which the author-editors apply the term, but during the entire century. Communist and fascist writers of all kinds agreed that the traditional western civilization, referring primarily to that of Europe, had decayed, and many West Europeans shared the same view, although for other reasons. Oswald Spengler's *Decline of the West* appeared soon after World War I, André Siegfried's book documenting the decay of England, *England's Crisis*, was published in 1931, Alexander Werth wrote of the *Twilight of France 1933–1940* (1942), and Pertinax published *The Gravediggers of France* in 1943. Non-Westerners like Gandhi and Nehru and leaders of the Muslim world saw in the European passion for war evidence of spiritual decay; an American historian has recently written that 'Europe ended its century of progress in an orgy of violence from which it never recovered' (Gordon A. Craig, *Europe since 1815*, London, 1961, p. 488). Writers noted that the area whose fate they were discussing shrank in size under the impact of communism and fascism, considering the strength of the forces hostile to the traditional civilization as evidence of decay. Some authors found evidence of decay in certain aspects of European life, especially in the political, economic and social areas, but they were impressed with the vigour of activity in scholarly fields like physics and mathematics, medicine and psychiatry, and in literary, artistic and musical creativeness.

The victory over fascism and the revival of political and economic life in Western Europe have led to a reassessment of the interwar views. Several commentators upon the present manuscript have taken exception to the use of the term 'decay of Europe' to refer to the interwar period. Professor Zurayk prefers the phrase 'decline in power' or 'decline in influence'. Professor Halecki thinks that the 'consequences of . . . the "Decay of Europe"' are 'overemphasized' and regards the expression as 'being inevitably offensive to Europeans, especially in contrast with the much more sympathetic approach to all other peoples'.

The development of a 'European Spirit' since World War II has been much discussed as a reality, and some writers define Western Europe as a Third Force, which maintains itself as an independent political and cultural unity between the communist bloc and the non-European world. See *L'Esprit européen* (Neuchâtel, 1947) as an example: it is a complete record of the proceedings of the first 'Recontres Internationales de Genève', held in the summer of 1946.

8 Professor Lázló Zsigmond makes the point that the cause of the collapse of Austria-Hungary and the formation of national states was the national-liberation movement

of the peoples who inhabited the area. Mention should also be made, in his opinion, of the formation of the Hungarian Soviet Republic in 1919.

9. Professor László Zsigmond expresses the opinion that it was not Soviet Russia that was the enemy of Western Europe, but the reverse: the imperialist Western Powers, which between 1919 and 1922 organized the intervention against the Soviets, were hostile to Soviet Russia.

10. Professor Lázló Zsigmond believes that in 1940 the French people were capable of resistance but lacked determination. The 'collapse' was the result of treachery on the part of certains groups within France.

11. Professor L. I. Zubok maintains that the political manœuvres directed by the United States against the extreme and overt forms taken by Japan's expansionist course in the late 1930s were half-hearted. Thus, for example, US Secretary of State Cordell Hull, at the same time as he called for the Japanese aggressors to be restrained, told the Japanese ambassador in a conversation on June 13, 1937, that the United States was taking up a 'friendly, impartial position' towards Japan in connection with the conflict in China (see *Papers Relating to the Foreign Relations of the United States: Japan 1931–41*, Washington, Vol. I, p. 321). On September 28th Hull wrote to the American observer at the League of Nations that the United States was not prepared to take part in collective sanctions against Japan (*Peace and War: Foreign Policy, 1931–41*, Washington, 1943, pp. 381–2). Throughout the period of Japanese aggression, almost up to the attack on the United States, a number of extremely influential American companies and trusts continued to supply Japan with very important types of strategic raw materials that she lacked, as well as with military *materiel*. In 1937 American commercial exchanges with Japan amounted to $288 million—considerably more than in the preceding year. In 1938 the total amount of American military supplies exported to Japan rose by 34·3 per cent, including metals by more than 300 per cent, machinery by 200 per cent, and aeroplanes almost by 500 per cent (T. Bisson, *American Policy in the Far East, 1931–40*, New York, 1940, p. 85). Even after the denunciation of the Japanese–American commercial treaty of 1911 (on July 27, 1939), Japan continued to receive strategic military supplies from the United States: in 1939 sales exceeded the 1938 level by 34 per cent.

12. The class character and causes of the events in Hungary in 1956 are explained in the resolution of December 1956 passed by the Central Committee of the Hungarian Socialist Labour Party and in the resolutions of VIIth Congress of this party (December 1959). In these resolutions it is stated that the counter-revolution was brought about by four simultaneously operating factors: the errors of the former sectarian leaders of the Hungarian Workers' Party, the (treacherous) activity of the revisionist group of Imre Nagy, the internal bourgeois counter-revolutionary forces, and the subversive activity of world imperialism. Since the 'counter-revolutionary uprising unleashed in Hungary on October 23, 1956, threatened not only the Socialist achievements of the Hungarian people, its national independence, but also the entire socialist order, peace in Europe and in the world as a whole', the new-formed Hungarian 'Revolutionary Workers' and Peasants' Government turned for aid to the armed forces of its ally, the Soviet Union, in order to prevent an armed intervention by the Western imperialists and to avert a lengthy civil war. The fraternal support given by the Soviet Union was a remarkable demonstration of allied loyalty and proletarian internationalism, which prevented further bloody crimes by the white terror, helped the forces of Socialism to smash the armed forces of counter-revolution, and averted the danger of war.' (*A Magyar Szocialista Munkáspárt VII. Kongress-zusának jegy-zökönyve*, Budapest, 1960, pp. 563–4).

13. The text has been severely criticized by scholars in the West European liberal and Catholic traditions for avoiding the use of the term 'totalitarian' and not treating totalitarianism as such as one of the central developments of the period. Professor Wilhelm Röpke

(Switzerland), Professor Hans Kohn (United States) and Professor Giorgio Janiot (Pontifical Gregorian University) believe that failure to focus upon totalitarianism as such affects the entire perspective from which events of this period are interpreted.

14. *The Author-Editors have not wished to minimize the significance of the tendencies to create monolithic societies and to reject the concept of the pluralistic, open society which has dominated the development of Western Europe and the spread of West European culture and influence around the world since the sixteenth century. They have avoided the term 'totalitarian' because it seems likely to impede rather than to facilitate the effort to see and analyse the similarities and differences in the institutions, social and political objectives and practical realities of the different regimes which have been established or maintained during these years. They have tried to use more precise, less comprehensive and less emotionally charged terms in order to examine the reality of all types of regimes, seeking the inner consistency of each and noting how their institutions reflect common or differing responses to conditions of industrial society and currents of thought of the period.*

CHAPTER II

THE IMPACT OF NATIONALISM AND TREND TOWARD INTERNATIONAL CO-OPERATION

AMONG the Fourteen Points which President Woodrow Wilson proposed as a basis for settlement of the first world war were two which embodied major dynamic trends of the twentieth century—the principle of self-determination of peoples and the proposal to form an international organization which should afford mutual guarantees of political independence and territorial integrity to great and small nations alike. To Wilson, with his ideal of a world order composed of free and democratic peoples, these were complementary proposals, each in line with the imperatives of the age. Both were welcomed by the peoples of the world as offering hope for the fulfilment of their deepest aspirations. Yet in a measure they reflected conflicting trends, nationalism versus internationalism. The resolution of the conflict between these two trends was the central and incomplete process of the years which followed.[1]

Wilson conceived of nationalism as a liberating force—and so it proved to be, not only in the east European areas which he had primarily in view but even more importantly in the colonial empires to which Lenin in the same period addressed his call for the liberation of subject peoples. But the idea of self-determination also gave a new lease on life to the driving, aggressive, competitive nationalism which had come to a tragic head in the first world war.

Wilson hoped that the international organization, the League of Nations, would hold aggressive nationalism in check and protect the aspiring nationalism of liberated peoples from the designs of their stronger neighbours. But the forms of nationalism which developed in the following years were more virulent than those previously known. The international organization was powerless to avert the ensuing conflict. A second holocaust was the awful price paid by the world.

When the world once more emerged from the hell of modern war, liberating nationalism and desperately needed internationalism again became the foundations of the world's peace and reconstruction. Liberating nationalism this time found expression in the new nations of ex-colonial peoples who emerged as a new world force. Internationalism was embodied in the United Nations and its many specialized agencies.

The new internationalism differed from the old both in the comprehensiveness of the international organization and in the nature of the divisive forces with which it had to cope. For the issue in the decade following the second world war was not only whether internationalism could stand up to aggressive

nationalism but whether it could bridge the gulf in a world which was ideologically divided. Its task was to enable the 'free world' and the communist countries to live together and the liberated peoples to develop as free nations in peace.

I. THE IMPACT OF NATIONALISM[2, 3]

Nationalism, which provided so much of the dynamic force for the shift in world power in the first half of the twentieth century, was in essence a state of mind in which the supreme loyalty of the individual was accorded to the nation-state and his identity as a person was bound up with membership in his nation. National loyalty replaced or overshadowed other forms of loyalty—personal loyalty to feudal lord or other leader, loyalty to family, village, craft or religious group. As an alternative to these personal loyalties nationalism offered identification with a broader and more generic concept, the people. The national state was an instrument by which the combined power of a multitude of men could be focused on a common goal, on the basis of the common obligation of all to a common entity.

Since modern nationalism implied the identification of state with people, its corollary was that people should form nation-states of their own. This was in contrast, not only to the concepts of more limited loyalty to feudal lord, town, monarch or religion, but to such traditional concepts of universality as Christendom or Islam, and to such supra-national political structures as the Ottoman, Austro-Hungarian and Russian empires.

Modern nationalism not only identified the individual with the nation-state in his political loyalty but identified civilization with national differences. By substituting the vernacular language, the folk traditions and the historic experience of each national unit for a language of international culture and a concern for universal truth, it added the concept of national civilization to that of national political identity.

The kinds of nationalism which were at work in the twentieth century differed in their temper and implications. In one of its forms, most vigorously manifested in the heritage of the American revolution, the spirit of nationalism was associated with the rationalism, liberalism and humanism of the eighteenth-century Enlightenment. In the theory of that time the act of nation-forming was a voluntary act—the social compact which John Locke and Jean-Jacques Rousseau had formulated on the basis of the traditional concepts of natural right. Peoples had become nations because they had chosen to band together to establish civil authority. The nature of this process implied the continued active participation of the people, who were the state. The national state was a rational expression of recognized human need, a defence against personal aggression and a stepping-stone to the liberation of mankind.

The terms in which President Wilson asked for the self-determination of peoples were those of liberal nationalism, for this was his tradition and that of

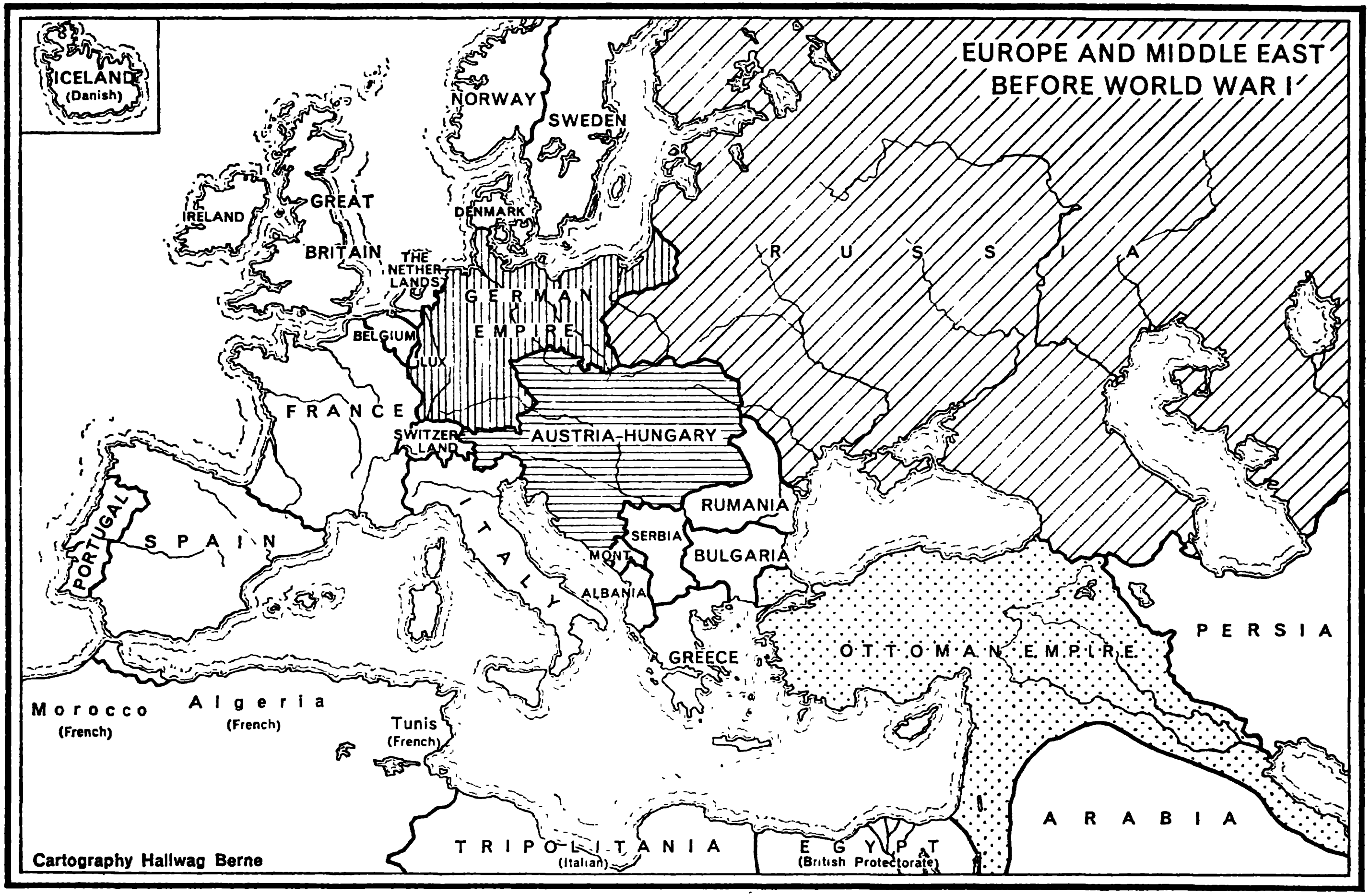
his nation, most of whose people had become Americans by choice in successive waves of immigration.

Throughout much of the nineteenth century in Europe nationalism was associated with the rising or dominant middle classes. In the national state of that time 'the people' were the propertied classes who, alone, enjoyed the suffrage in most countries. The interests of the state—identified with the goals of nationalism—were primarily the interests of the commercial and industrial groups. It was they who most thought of themselves as the nation. The aristocracies of Europe had many family ties abroad, and a more international outlook. The non-propertied elements in the population—small or landless peasants, industrial workers—who did not participate politically did not identify themselves psychologically with the nation-state in the same degree as did the *bourgeoisie*.

In the late nineteenth and early twentieth centuries identification with the nation-state spread through more strata of European society as these became literate and were incorporated more completely into national life. By the outbreak of the first world war the process was so far advanced that alternative loyalties could not stand against loyalty to the national state. Leaders of European labour thought that the common interests of the working classes were greater than national interests and they counted on these ties to prevent a resort to war. But the Second International, which united the socialist parties of Europe and represented the solidarity of labour, broke down in 1914 in the face of the national feeling of the working classes who followed their leaders in supporting their governments. Any lingering reservations were overcome by the impact of total war.[4]

European nationalism in the nineteenth and early twentieth centuries tended to be expansionist and competitive. Expressing dominant commercial and industrial interests, it pressed for markets, raw materials and opportunities for foreign investment. How aggressive the nationalist drive might be depended in each case upon the position of the particular country. Britain, which had been the first to develop modern industry and whose empire contained twice the geographical area and seven times the population of the next largest imperial power, France, could advocate free trade and enjoy a comfortable sense of national identity and superiority without the necessity for intense, nationalistic passion. By contrast, Germany, whose unification, industrial development and entrance into the competition for empire came late, felt the need to struggle to make a 'place in the sun' for itself as a great power.

Aggressive nationalism drew much of its spirit and rationale from the concepts of nationalism formulated by the nineteenth-century German romantics in a non-rational, non-liberal spirit. In this theory, nationalism was deemed to rest on the *Volksgeist* expressing man's instincts, not his reason, to reflect the circumstances of birth and blood and to derive from historic experience, not conscious choice. This concept of nationalism emphasized


EUROPE AND MIDDLE EAST
BEFORE WORLD WAR I
ICELAND
(Danish)
NORWAY
SWEDEN
GREAT
BRITAIN
IRELAND
DENMARK
THE
NETHER-
LANDS
GERMAN
EMPIRE
BELGIUM
LUX
FRANCE
SWITZER-
LAND
AUSTRIA-HUNGARY
RUSSIA
PORTUGAL
SPAIN
ITALY
RUMANIA
SERBIA
BULGARIA
MONT.
ALBANIA
GREECE
OTTOMAN EMPIRE
PERSIA
ARABIA
Morocco
(French)
Algeria
(French)
Tunis
(French)
TRIPOLITANIA
(Italian)
EGYPT
(British Protectorate)
Cartography Hallwag Berne

loyalty to an entity which transcended those who made up the nation, and it was compatible with authoritarian rule. It tended to view the uniqueness of each nation as permanent and divisive rather than as an aspect of common brotherhood.

Competitive nationalism built up world tension, and though the broadened base of nationalism led to social reform at home, it tended to enhance the emotional component of nationalism abroad and to strengthen its romantic, irrational, non-liberal aspects. The final expression of competitive nationalism was the first great war of peoples.

This was the kind of nationalism that Wilson hoped to hold in check by international organization, as did all who rallied to him eagerly at the close of the war, convinced that the response to the tragedy of some 13,000,000 dead and 7,000,000 permanently disabled must be, 'Never again'.

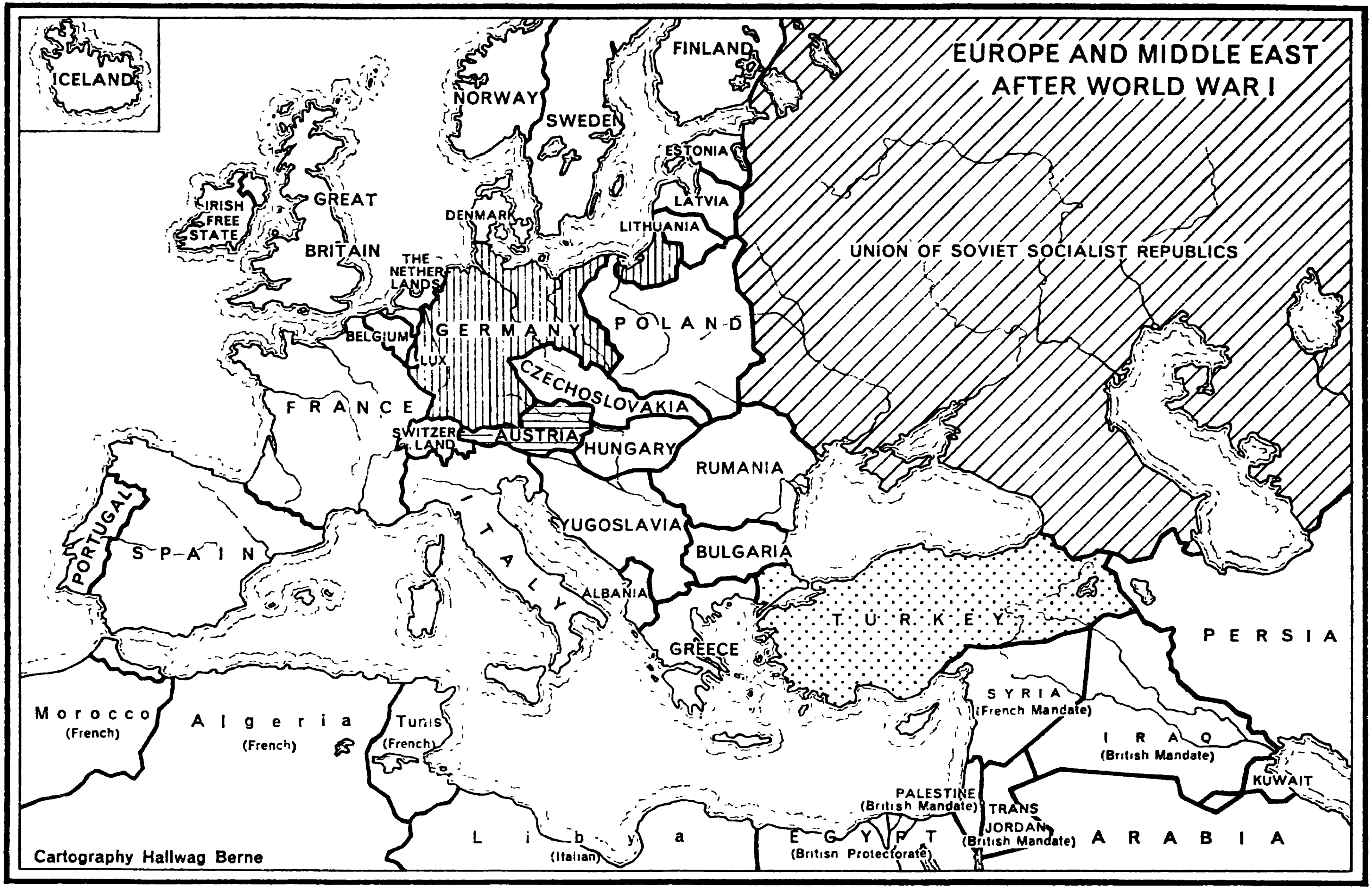
While nationalism permeated the societies of western Europe and the Americas, the concept was growing stronger in eastern Europe and Asia, to produce ferment among the peoples of the Austro-Hungarian, Russian and Ottoman empires, to break out in anti-foreign attacks in China and to reach colonial India with the establishment of the Indian National Congress in 1885. In these areas, as in Europe, it was at that stage mainly the rising middle classes of civil servants, professionals, clerical workers and merchants which became the bearers of nationalism. Even in such an area as Indonesia where the middle class was small, the first nationalist movement in 1908, *Budi Utomo* (Fair Strive), was composed of western-trained intellectuals, and it was followed some years later by a half-religious, half-nationalist movement of merchants, *Sarekat Islam*, which was joined by other groups such as school teachers and clerks.

In the areas to which nationalism spread, as in the lands of its origin, devotion to the nation-state came in time to embrace broader segments of the population. As nationalist movements in colonial areas became mass movements they inevitably also became movements for the reconstruction of society as well as for its liberation from foreign yoke.

Asian nationalism thus followed a course of development similar to that in Europe but at a very much more rapid pace. The process of national identification, first with ruler, then with *bourgeoisie* and finally with the totality of the people, that had taken place in Europe gradually through some four hundred years was virtually completed in Asian countries in as many decades. In Africa the pace was faster still.

European nationalism had developed along with the growth of political and economic institutions. It had taken shape in nations which functioned as going concerns and whose economic and political basis was strong and broadening. It had expanded to embrace broader classes in the population as these became more active participants and beneficiaries.

Asian nationalism, however, developed among the intellectuals and then among the masses of the people long before an adequate institutional basis for national life had been established. In so doing it released an immense


EUROPE AND MIDDLE EAST
AFTER WORLD WAR I
ICELAND
NORWAY
SWEDEN
FINLAND
ESTONIA
LATVIA
LITHUANIA
IRISH FREE STATE
GREAT BRITAIN
DENMARK
THE NETHERLANDS
BELGIUM
LUX
GERMANY
POLAND
UNION OF SOVIET SOCIALIST REPUBLICS
FRANCE
SWITZERLAND
AUSTRIA
CZECHOSLOVAKIA
HUNGARY
RUMANIA
PORTUGAL
SPAIN
ITALY
YUGOSLAVIA
BULGARIA
ALBANIA
GREECE
TURKEY
PERSIA
Morocco
(French)
Algeria
(French)
Tunis
(French)
SYRIA
(French Mandate)
IRAQ
(British Mandate)
KUWAIT
PALESTINE
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TRANS JORDAN
(British Mandate)
ARABIA
Libya
(Italian)
EGYPT
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emotional force which could provide a great stimulus to national efforts and at the same time could overshadow the practical realities of national progress.

The first impact of the stimulus to nationalism from the enunciation and acceptance of the principle of self-determination of peoples was to loosen the hold of multi-national empires, to encourage national movements among minorities within national states, such as the Flemish in Belgium or the Catalans in Spain who wanted the use of their own language, to strengthen movements for independence, as in Ireland, and to give great encouragement to nationalist movements among colonial peoples.

These were generally liberating effects but they contained within themselves disturbing tendencies. How small a group was a people or a nation? In an economically interdependent world an invitation to every minority with historic consciousness to seek statehood was an encouragement to the fragmentation of society. The romantic concept of national history as a basis for nationalism, moreover, led immediately to conflicting claims, especially in eastern Europe where each country appealed to the period in history when the element with which it was identified nationally had ruled over the largest area. The idea that people of the same ethnic background belonged together, furthermore, brought claims for reunion with fellow-nationals living outside the national area. The wholesale exchange of Greek and Turkish populations in Asia Minor and Macedonia in 1922 removed millions of people from what had been their homelands for many generations, to bring them under the jurisdiction of their 'own' national states. These were but the first of many groups of displaced persons who were to become one of the twentieth century's most characteristic and tragic monuments to nationalism. For those minorities who had no nation to which to go, the liquidation of the Armenian population of Turkey foreshadowed the fate that was later to befall the Jews in Europe.

Within a few years of the hopeful enunciation of the principle of self-determination aggressive nationalism reasserted itself with renewed vigour. Japanese nationalists launched their expansionist venture in Asia, while in Europe a type of aggressive nationalism arose which went far beyond any hitherto known. First in fascist Italy and then in an even more extreme form in Nazi Germany, the implications of romantic nationalism were pushed to their furthest limits. The individual's supreme loyalty to the nation-state became his complete subjection to it; his identification with the aims of the nation became the surrender of every independent basis for organization; the nationhood of birth and blood became Aryanism, extermination of the Jews and the concept of the 'great-German Reich' composed of all German peoples wherever they might be; and finally the claimed natural superiority of the German folk was taken as a warrant for the expansion of the German state. This was the new, aggressive nationalism of the 1920s and 1930s which took the world to a second world war.

After the second world war, nationalism remained a major world force. It

brought the liberation of the peoples of Asia and Africa. Its most aggressive forms appeared, for the moment at least, to have been checked. In the decade after the war it seemed to be compatible with the new internationalism. But by the middle of the twentieth century nationalism had shown itself to be a dangerous as well as a creative force in the life of mankind. And the interrelations among political units, both within and between states, had become infinitely complex in a world which was increasingly interdependent and at the same time increasingly bent on self-determination.

II. THE GROWTH OF INTERNATIONAL CO-OPERATION

The very forces making toward nationalism pressed at the same time beyond nationalism to international co-operation. Industry had required wider territory than the local village or feudal domain, and the national state had been in part an answer to its need for markets, for regulations extending over a large area to permit transactions under cover of law, uniform monetary systems, guarantee of contracts and legal recourse in case of their violation, as well as for transport facilities, financial institutions, labour recruitment and all the elements of modern industrial society. But as industry expanded and technology made possible fast transport and communication, national boundaries became too narrow, national regulations and facilities were insufficient, and many types of international bodies were set up. The International Telegraphic Union dated from 1865 and the Postal Union from 1874; international conventions for patents and copyrights were adopted in the 1880s; the International Court of Arbitration was established at The Hague in 1899. Starting with the International Geodetic Association in 1864, virtually all fields of science were internationally organized, as were many of the arts. International co-operation in the field of labour had been inaugurated with the First International in 1864, followed by the Second International in 1889.

The groundwork thus already existed for a major effort at international organization when the nations, staggering to their feet after the long, disastrous strain of the first world war, found the need for such organization to be imperative.

1. *The League of Nations*

Yet the League of Nations was radically new in conception and structure. For it proposed to commit states in advance to certain courses of action, and to provide judicial machinery which nations might, if willing to do so, use for the adjudication of disputes.

The Covenant of the League of Nations, drafted as an integral part of the treaty of Versailles, provided in its preamble that:

The High Contracting Parties, in order to promote international co-operation and to achieve international peace and security by the acceptance

of obligations not to resort to war, by the prescription of open, just and honourable relations between nations, by the firm establishment of the understandings of international law as the actual rule of conduct among Governments, and by the maintenance of justice and a scrupulous respect for all treaty obligations in the dealings of organized peoples with one another, agree to this Covenant of the League of Nations.

Three points stood out clearly: the obligation not to resort to war; the creation of a new international law as the actual rule of conduct among governments; and scrupulous respect for all treaty obligations. These were not to be merely pious expressions; the Covenant provided machinery by which they should be enforced. Any member who might resort to war in disregard of its covenants was 'deemed to have committed an act of war against all other members', and these undertook to subject the covenant-breaking state immediately to economic sanctions by cutting off all trade and economic relations with it. Collective security supported by sanctions was a revolutionary principle.

A complementary provision, meant to develop the new spirit of international law under which the states were to settle their disputes, created a Permanent Court of International Justice, which should be 'competent to hear and determine any dispute of an international character' referred to it by the parties and to give an advisory opinion on any question or dispute referred to it by the Council or Assembly of the League of Nations.

In an effort to prevent disagreements from developing into disputes which might threaten the peace the Covenant gave every member 'the friendly right' to bring to the attention of the League's Assembly or Council any circumstance which might disturb 'the good understanding between nations on which peace depends', thus affording the League an opportunity to intervene and mediate.

The League was intended as a world organization and not merely a continuation of the concert of Europe. It was to include in its membership every independent state. The Latin American states and five Asian countries—Japan, China, Siam, Persia and India—were original members of the organization; India, though not independent, was admitted to membership on the ground of her exceptional contribution to the war. In the League's Assembly member states were represented on a basis of sovereign equality. Its Council, however, reflected the structure of world power, for the allied great powers, Britain, France, the United States, Italy and Japan, were to be permanent members, while four others were to be elected periodically from among the rest.

But the League, in fact, never became a world organization. The principle of universality suffered a staggering blow from which it never recovered when the United States decided not to join the organization. Also, Germany and the Soviet Union, though admitted later with permanent seats on the Council,

were not associated with the League in its formative stages. Japan, Germany and Italy subsequently withdrew when they wished to act in defiance of the League's decisions.

The Assembly, which included all the smaller countries, met only annually at the League's headquarters in Geneva as a sort of international gathering. The League's authority was exercised by the Council whose permanent members tended to make the League their instrument. Furthermore the guarantee of the territorial integrity of nations included the overseas possessions of European states, thereby aligning the League on the side of the imperial powers against nationalist movements.

The authority of the League was soon tested. Challenged by the new and virulent form of nationalism, it was quickly shown to be ineffective. In 1923, a few months after Benito Mussolini had marched on Rome to establish the first of the fascist states, Italy became involved in a controversy with Greece. Instead of negotiating the dispute she sent a twenty-four hour ultimatum to the Greek government, which in turn appealed to the League of Nations; but before the League could even meet, Italy had bombarded and occupied the island of Corfu. The League merely handed over the matter to the Council of Ambassadors. Mussolini had proved to the world the impotence of the world organization.

From that time on, no major issue was decided by the League. The Locarno pact of 1925 and other attempts by the powers to find direct remedies for their fears were in fact confessions of the League's ineffectiveness. When Japan invaded Manchuria in 1931 the League found that even with the active support of the United States it was in no position to enforce any decision against the invader. The only result of its declarations and actions, including non-recognition of the puppet state of Manchukuo, was Japan's withdrawal from membership in the League. This incident removed all doubt as to the League's fatal weakness.

The League did invoke economic sanctions when Emperor Haile Selassie of Ethiopia in 1935 appealed to it for support in the face of Mussolini's attack on his country. But the response of the member states was so half-hearted that the damage to the League's prestige was far greater than to the Italian economy, although Italy was lacking essential raw materials and highly vulnerable to a systematic cutting off of supplies. The apparent indifference of the European statesmen to the fate of the last historic free state of Africa seemed to the weak nations and the colonial peoples of the world to confirm their suspicions that the League was no more than a cloak for the continuation of the old power politics of the 'haves' at the expense of the 'have-nots'. The League stood helplessly by while Hitler, one of whose early acts was to withdraw Germany from the League, scrapped one provision of the Treaty of Versailles after another, and it made no serious attempt to use its authority when Italy and Germany intervened directly in the Spanish civil war in 1936. Its only firm gesture, the expulsion of the USSR on the charge that the

Soviet–Finnish conflict of 1939–40 constituted aggression, came after the second world war had already broken out.[5]

Thus the first effort to create an international world organization which would ensure collective security failed to check the aggressive nationalism of the fascist powers and to avert a second world war.

Yet although it failed in its major task, the League of Nations, through the technical bodies it established, the studies which it conducted, conferences it organized and conventions which it formulated in many fields, contributed substantially to the building up of a world community and helped to develop the habit of approaching matters of common concern in international terms. Its most notable and enduring achievements were in the field of labour, where the International Labour Office through patient and unspectacular work brought workers, employers and governments together to develop world standards and principles concerning hours of work, industrial health and safety, employment of children and young people, maternity protection, protection of wages and related matters. The International Labour Office became so well established in its work and so generally accepted that it survived the shock of the second world war to emerge as one of the specialized agencies of the United Nations.

In making provision for the administration of Germany's former colonies and of part of the former Ottoman empire, the League developed three classes of mandates, adapted to the presumed political maturity of each area, under which administration was to be primarily for the benefit of the people of the area, not the mandatory power. The latter was responsible to the international body for the conduct of its rule. Although the system as it worked out was a long way from achieving its announced goals, it helped to undermine the principle of colonial authority and laid a basis for the trusteeship system of the United Nations.

In many social fields as well, such as health, nutrition, international traffic in women and in drugs, highway safety, population study, the League developed practical machinery for international co-operation and laid the basis for the United Nations and its specialized agencies. Its International Institute of Intellectual Co-operation presaged the formation of UNESCO.

Thus the practice of international co-operation was built up in numberless ways, at the same time that the destructive forces of aggressive nationalism were precipitating world conflict.

2. *The United Nations*

Although the outbreak of the second world war put an end to the League of Nations, it was clear that a new international structure must emerge once hostilities should cease, and during the war steps toward this objective were taken. The declaration of principles contained in the Atlantic Charter, formulated in 1941 by the British prime minister, Winston Churchill, and the

president of the United States, Franklin D. Roosevelt, was adhered to by fifty-seven countries before the end of the war. Declarations of their intention to create a world organization were made by representatives of Great Britain, the United States, the Soviet Union and China at Moscow in 1943 and by Churchill, Roosevelt and Stalin at Teheran in the same year. Draft proposals for a general international organization were formulated in 1944 at Dumbarton Oaks in the United States as a result of conversations between the United States, the Soviet Union and Great Britain to which China was later a party. Finally, as the war was drawing to a close in April 1945, forty-six nations sent delegates to a meeting in San Francisco, USA, to formalize the creation of the United Nations Organization and agree upon its charter.[6]

The purpose of the United Nations as stated in the preamble to its charter was broader than that of the League of Nations, for it reaffirmed 'faith in fundamental human rights, in the dignity and worth of the human person' and it called specifically for employing international machinery 'for the promotion of the economic and social advancement of all peoples' as well as 'to unite our strength to maintain international peace and security'. Like the Council of the League, the United Nations Security Council was composed of five great powers as permanent members—Great Britain, USA, USSR, France and China—and rotating members elected for two-year terms from among other states.

The United Nations succeeded, where the League had failed, in becoming genuinely a world organization. As the former colonial peoples gained their independence they took their places one by one in the international body. Year after year the membership grew. Fifty nations signed the charter on June 26, 1945, to bring the organization into existence; by 1957 there were eighty-two with more to come as successive African states should achieve their independence. For areas still in colonial status, it exercised supervision of former mandates and other trust territories and its Trusteeship Council called upon all metropolitan governments to supply periodic reports on the administration of their dependencies. However much the great powers might seek to use the United Nations, it could not be regarded on the whole as the bulwark of their interests. The main gap in the organization's structure during the 1950s was the absence of the Chinese People's Republic with nearly a third of the world's population.

The chief channel for the influence of the smaller countries came to be the United Nations Assembly which grew in importance through the years. The influence of the League's Assembly had been slight; though it had held some dramatic sessions, as when Emperor Haile Selassie appeared before it to plead Ethiopia's cause, the League had acted almost entirely through its Council. The drafters of the United Nations charter expected a comparable development. But in the early period of its existence some members of the Assembly, notably the delegate of Australia, made an effort to bring more and more subjects before the Assembly for debate and to establish its independent right to take up and act by majority vote upon matters of its choice. At the same

time the Security Council was persistently split by the division between communist and non-communist countries and prevented from action by the veto which each permanent member enjoyed and which was used no less than seventy-seven times by the USSR in the course of the first ten years as its way of maintaining its point of view in a body where four of the five permanent seats were held by non-communist powers.[7]

In these circumstances the United Nations Assembly became a forum for the expression of world opinion—opinion which came more and more to reflect the views and aspirations of those who had played little or no part in the League of Nations.

In the first decade of its existence the United Nations functioned in the shadow of tension between the communist and non-communist blocs. It acted in 1950 to declare North Korea an aggressor and to mobilize member nations in South Korea's defence, but the action was taken by the Security Council at a moment when the USSR chose to boycott the session and was not present to exercise its veto.[8] When Israel marched against Egypt in 1956 and Britain and France sent an expedition against Suez, world opinion, mobilized through the United Nations Assembly, halted the Suez expedition and caused the withdrawal of the victorious Israeli and Franco-British forces; the United Nations assumed responsibility for policing the Egypt–Israel truce line with an international police force and, by agreement with Egypt, for clearing and reopening the blocked canal. Simultaneously, however, United Nations protests failed to halt the use of Soviet troops to suppress a revolt in Hungary and the secretary-general of the United Nations was denied entrance into Hungary either as a mediator or as an observer.[9]

After fifteen years the most striking thing about the United Nations was that it had withstood the world forces constantly threatening to tear it apart. Although nations had walked out of its meetings, none had left the organization. Whatever its failures, its efforts persisted in the deep conviction that some kind of international organization must be kept alive.

Meantime, through its many specialized agencies, its Economic and Social Council, its Commissions on Human Rights and on the Status of Women, its Technical Assistance Board and its other instrumentalities, it developed a great body of co-operative international activity in economic and social fields. The World Bank for Reconstruction and Development provided an international means for bringing foreign capital into underdeveloped areas without the imperialist implication which such investment had often carried in the past. International technical assistance missions in agriculture and health, welfare and industry, education, administration and countless other fields responded to requests for aid from governments around the world. UNESCO acted as a stimulus to intellectual co-operation. Through all these practical programmes the United Nations pursued its declared purpose 'to promote social progress and better standards of life in larger freedom'.

3. *Tendencies in international law*

Along with the creation of international organizations went the development of international law. The League of Nations mandate system involved a direct assumption of international responsibility. So also did the recognition of statelessness as a status under international guarantee, in response to the problem created by large numbers of refugees from revolutionary régimes; travel papers based on this special status became a factor of considerable importance. The conventions drafted by the International Labour Organization came to constitute an internationally recognized code of labour standards, while those relating to the control of white slave traffic and narcotics imposed direct obligations upon the signatories. And though its efforts were unsuccessful, the League of Nations did attempt to enforce sanctions against two major powers, Italy and Japan, for what it considered breaches of international law. The collective action of the majority of members of the League in protest against the Italian invasion of Ethiopia deserves to be remembered as the first effort to enforce an international decision against a major power.

The most noteworthy step was the creation of the Permanent Court of International Justice by the League of Nations. Although only those countries which agreed to do so were bound to accept the jurisdiction of the court when a case was brought against them, and though the basic issues involving the peace of the world did not come before the tribunal for adjudication, the court decided thirty-two international cases during its eighteen years of existence, and in no case was its judgment defied. Its work was carried on after the second world war by the International Court of Justice created by the United Nations.

The establishment of the United Nations and its specialized agencies was accompanied by a further growth in international law—the gradual evolution of a system of enforcement manifested in the creation of token international forces such as the neutral commission in Kashmir and the international police force in the Gaza strip and the Sinai peninsula; in the decision to halt war as in the case of the two 'police actions' of the Dutch in Indonesia or to engage in war on behalf of the United Nations when the sovereignty of a country was invaded as in Korea or the Anglo-French attack on Suez; and in the growing tendency of the United Nations to override the plea of internal sovereignty where human rights were involved, notably in resolutions condemning racial policies in South Africa and discussions of French military activity in Algeria. On a regional basis, the Organization of American States provided mutual guarantees of non-intervention among the states of the western hemisphere and the League of Arab States undertook a somewhat similar function in the Middle East. Efforts to unite western Europe envisaged the possibility of a European parliament, growing out of steps toward economic co-operation.

In short, the developments during this period bore witness to the growth

of a collective consciousness and a desire on the part of the world community to enforce, even against powerful nations, certain moral and ethical principles, thus giving them the force of international law.[10]

NOTES TO CHAPTER II

1. Academician D. Kosev argues that it was the October Revolution in Russia, and not Wilson's Fourteen Points, that exercised the principal influence upon the spread of the revolutionary movement in Europe and the national-liberation movement in the East.

The same point is made by Professor László Zsigmond, who finds it impossible to agree with the authors' statement that national self-determination and national independence are incontrovertibly connected with the Fourteen Points of President Wilson.

Professor L. I. Zubok and Doctor of Historical Sciences V. M. Dalin note that the Great October Socialist Revolution opened a new era in history—the era of the collapse of imperialism and the establishment of a new socialist society—and exercised a decisive influence upon the destinies of peoples the world over. It brought about a mighty upsurge in the revolutionary and national-liberation movement in all countries and marked a new stage in the struggle of the working masses for socialism. From the time of the October Revolution onwards the development of world history has proceeded under its steady influence. The period immediately following the socialist revolution in Russia (1918–23) is known as *the period of revolutionary upsurge* in the capitalist countries and *the upsurge of the national-liberation movement* in the colonial and dependent countries.

J. Nehru, Prime Minister of India, and President Sukarno of Indonesia, assess the significance of the October Revolution in the following words:

'. . . I had no doubt that the Soviet revolution had advanced human society by a great leap and had lit a bright flame which could not be smothered, and that it had laid the foundations for the "new civilization" towards which the world would advance.' (J. Nehru, *The Discovery of India*, New York, 1946, p. 17).

'During the October Revolution the Russian people showed the peoples of Asia who were fighting colonial oppression that the working class could overthrow the mighty power of a cruel feudal regime, in this case the tsarist autocracy, and build the new society of which they dreamed. This great historic event, which took place beyond the limits of the Asian continent, had a striking effect upon the peoples of Asia who were struggling for national independence, and enhanced their confidence that in the long run they too would win victories in their struggle for justice, if they fought in an organized manner and with all the determination they could command. After the success of the October Revolution in Russia, the struggle of the Asian peoples for national independence, against the oppression of the invaders, burst forth with fresh intensity.' (Sukarno, 'The Influence of the October Revolution on the Awakening of the Peoples of Asia', *Pravda*, October 11, 1956.)

See also the following:

Velikaya Oktyabrskaya revolyutsiya i mirovoye osvoboditelnoye dvizhenie ('The Great October Revolution and the world-wide Liberation movement') Moscow, 1958).

Mezhdunarodnoye znacheniye Velikoy Oktyabrskoy sotsialisticheskoy revolyutsii ('The international significance of the Great October Socialist Revolution') (Moscow, 1958).

Vsemirno-istoricheskoye znachenie Velikoy Oktyabrskoy sotsialisticheskoy revolyutsii ('The world-historical significance of the Great October Socialist Revolution') (Moscow, 1957).

Velikiy Oktyabr i narody Vostoka ('The Great October Revolution and the Peoples of the East') (Moscow, 1957).

Die Auswirkungen der Grossen Sozialistischen Oktober Revolution auf Deutschland, Bd 1–4, (Berlin, 1959).

Tim Buck, *1917–1957. Forty Years of Great Change* (Toronto, 1957)
Contributii la studiul influentei Marii revolutii socialiste din Octobrie in Romania (Bucuresti, 1957).
Culinović, F., *Odjeci Oktobra u jugoslavenskim krajevima* (Zagreb, 1957).
Winston U. Solberg. *The Impact of Soviet Russia on American Life and Thought* (Cambridge, Mass, Harvard University, 1952).
Velka Rijnova Socialistcka revoluce v dejinach a kulture Ceskoslovenska (Praha, 1958).
Wplyw Rewolucji Październikowej na ruch spółdzielczy (Warszawa, 1958).
K. M. Panikkar, *Asia and Western Dominance* (London, 1954).
J. Romein, *De Eeuw van Azie* (Leiden-Brill, 1956).
J. Ingenieros, *Los tiempos nuevos* (Buenos Aires, 1957).
O. Brandao, *Russia Proletaria* (Rio de Janeiro, 1923).
A. Pereira, *Russia avanza* (São Paulo, 1924).
E. Recabarren, *Lo que vi en Russia* (Santiago de Chile, 1923).
K. Liebknecht, *Reden und Aufsätze* (Hamburg, 1921).
K. Mammach, *Der Einfluss der russischen Februarrevolution und der Grossen Sozialistischen Oktoberrevolution auf die deutsche Arbeiterklasse* (Berlin, 1955); and others.

2. Candidate of Philosophical Sciences E. D. Modrzhinskaya cannot agree with the way in which the authors treat the concepts of 'nation' and 'nationalism'.

(1) Following a school of thought that is widespread in the West, the authors understand by the word 'nation' first and foremost a state organization. Undoubtedly the creation of a state is an important element in the development of a nation; nevertheless it cannot be considered an indispensable sign of nationhood, since there have been, and still are, nations which have not had or do not have their own national state. To maintain that every nation must have its state would imply that many colonial and semi-colonial peoples that have not yet won statehood, but are still fighting for it, are not nations. Historical materialism teaches that the nation is an historically constituted, stable community of people, formed on the basis of a common language, territory, economic life, and psychological make-up manifested in a common culture.

All these hall-marks of nationhood are interconnected, and the presence of all of them is necessary before a particular community of individuals can call itself a nation. Nations first came into being during the epoch of developing capitalism, although certain elements of nationhood (language, common culture, etc.) were already formed during the pre-capitalist era.

(2) Nationalism is treated by the authors as though it were identical with some sort of 'national feeling in general'; the nationalism of ruling groups is equated with the patriotism of the popular masses, which they also call nationalism; and the nationalism found in colonial and dependent countries is confused with the aggressive nationalism of the colonialists. Soviet scholars take the view that nationalism is the expression of the policy of the bourgeoisie in the form of ideas and concepts, and that it reflects the attitude of the bourgeoisie to its own nation and to other nations; in other words, nationalism is a constituent element of bourgeois ideology. During the period when capitalism was in the ascendant, i.e. when bourgeois nations were first coming into being, nationalism was linked with a fierce and bitter struggle against feudalism and feudal exploitation. The broad mass of the people rose in revolt against feudal society; they were interested in the liquidation of serfdom and oppression by the privileged classes of feudal society; and in so far as the bourgeoisie fought against the feudal order, and genuinely acted on behalf of the nation as a whole, to that extent bourgeois nationalism had a progressive, general-democratic character. But victory in the struggle against feudalism paved the way for a new, capitalistic form of exploitation. A radical difference appeared between the class interests of the bourgeoisie, and the bourgeois ideology that reflected them, and the interests and ideology of the working masses. As capitalism developed, so this contradiction between the exploiters and the exploited became ever more intense. It is natural that in the era of the highest and last stage in the development of capitalism, imperialism—when there is a very deep gulf between the interests of the monopolists and the broad masses of the people —aggressive imperialist nationalism should have revealed particularly clearly its essentially anti-popular and reactionary nature. However, in this historical epoch, but in different concrete circumstances—

in countries where a struggle is being carried on against imperialist oppression—bourgeois nationalism has a progressive character in so far and inasmuch as it has a general democratic character and is directed against imperialist oppression.

This point of view is endorsed by Dr. Vavro Hajdu, who points out that the authors frequently identify the nation with its ruling class, and present the actions and interests of the ruling class as the actions and interests of the nation as a whole. Hajdu also considers that the authors' approach 'to the problem of nationalism is fundamentally incorrect, particularly in so far as the philosophical aspect is concerned. The efforts towards integration in Europe are presented as a new form of internationalism.'

3. *The Author-Editors have used the term 'nation state' to designate a state based on the presumed loyalty of all citizens and their presumed common interest and identity vis-à-vis other political units. They have used the term 'nationalism' to designate: (1) the aspirations for separate identity and political autonomy of a group of people identified by a common language, religion, culture, descent or tradition, and (2) the aspirations of a nation state to further what it regards as its interests as a body politic.*

4. Professor László Zsigmond, Dr Vavro Hajdu and Professor L. I. Zubok emphasize that a decisive part in bringing about the collapse of the Second International was played by its leaders, J. Guesde, H. Hyndman, E. Vandervelde and K. Kautsky, who adopted a position contrary to the resolutions passed on war and militarism with their participation at the Stuttgart congress (1907) and Basle congress (1912) of the International. At the beginning of World War I they repudiated internationalist slogans and supported their governments. See, for example, the declaration by the Social-Democratic fraction in the German Reichstag on August 4, 1914, to the effect that it supported the government in the war and was voting for the war credits requested (*Vorwärts*, August 5, 1914).

5. Doctor of Historical Sciences N. Yakovlev notes: The resolution on the exclusion of USSR from the League of Nations was taken on December 14, 1939, by the Council of the League. A pretext for this step was found in the armed conflict between the USSR and Finland. Of the 15 members of the Council only 7 voted in favour of the resolution: Great Britain, France, Belgium, Bolivia, Egypt, the Union of South Africa, and the Dominican Republic, i.e., less than one half of all the members and, besides, among the States voting there were two—Egypt and the Union of South Africa—which at that time were directly dependent upon Great Britain. Therefore, the resolution of the League of Nations could not have normal validity.

6. Doctor of Historical Sciences N. N. Yakovlev stresses that the first of the Powers belonging to the anti-Hitler coalition to declare officially that it was necessary to set up a new international organization was the Soviet Union. The declaration on friendship and mutual assistance signed between the USSR and Poland on December 4, 1941, stated: 'After the victorious conclusion of the war and due punishment of the Hitlerite criminals it will be the task of the Allied states to secure a lasting and just peace. This can be attained only by a new organization of international relations, based on the uniting of the democratic countries in a durable alliance.'

7. Doctor of Historical Sciences N. Yakovlev notes:

(1) When drafting the UN Charter, the American and British governments attached enormous importance to the principle of unanimity of the Great Powers in this Organization—the principle later known as 'the veto'. At that time unanimity of the Great Powers in the United Nations was regarded in Washington and London as a *conditio sine qua non* of the existence of the United Nations Organization. On this question there was not the least disagreement between the USSR, the USA, and Great Britain. C. Hull, the US Secretary of State during the war years, emphasizes in his *Memoirs:* '. . . There was no question in our minds, . . . that the vote of the permanent members of the Council should be unanimous on questions involving security. This was the so-called veto power. We were no less resolute than the Russians in adhering to this principle. . . . ' (C. Hull, *Memoirs*, New York, 1948, Vol. II, p. 1683.) E. Stettinius, who succeeded C. Hull as Secretary of State, pointed out that both the military and the civilian American leaders were anxious that the principle of unanimity of the Great Powers should be accepted. E. Stettinius wrote: 'The fact . . . that a major argument

against American participation in the League of Nations had been that membership would commit us in vital matters was of real significance in determining American support of the veto power by the permanent members (of the Security Council)'. (E. Stettinius, *Roosevelt and the Russians: the Yalta Conference*, New York, 1949, p. 19.)

(2) The representatives of the Western World also used the 'veto'. For example, in 1956 Great Britain and France made use of the power of veto when in the Security Council there was raised the question about the cessation of Anglo-Franco-Israeli hostilities against Egypt.

8. Professor L. I. Zubok and Dr Vavro Hajdu stress that the declaration that the Democratic People's Republic of Korea was guilty of aggression contradicts the facts. The facts show that aggressive actions were begun by the government of South Korea, relying upon the support of the USA. See the book I. F. Stone, *The Hidden History of the Korean War* (New York, 1952); also 'Documents and Materials Exposing the Inspirators of the Civil War in Korea': *Documents from the Archives of the Rhee Syngman Government* (Pyongyang, Ministry of Foreign Affairs of the Democratic People's Republic of Korea, 1950).

9. See Note 12 to Chapter I.

10. Professor László Zsigmond notes that, when enumerating various international organizations, the authors make no mention whatsoever of the Third International and other international labour organizations, such as the World Federation of Trade Unions.

CHAPTER III

THE NEW ROLE OF THE STATE AND ITS COMPETING FORMS

I. DEVELOPMENT OF THE INCLUSIVE STATE

IN the twentieth century the political state became more inclusive and demanding than it had ever been before. This was true in respect to those who participated in it, those whom it reached and served, and the scope of its functions and activities. The electorate on which governments rested was everywhere extended.

At the beginning of the century the governments of even the most advanced democracies rested on a limited franchise, for although direct property qualifications for voting had been gradually removed, indirect ones such as educational qualifications remained in some places, and women did not enjoy the right to vote. Outside western Europe, the Americas and Oceania political participation was far more restricted. Russia and the Ottoman empire were under autocracies; Japan, under a divine emperor, had a parliament based on limited suffrage; the empire of China was still ruled by the Manchus; few colonial peoples knew the meaning of the ballot, for even such legislative bodies as functioned in British-occupied India were elected on a restricted and indirect franchise.

By mid-century the position had changed radically. In the countries of Europe and the Americas the conception of 'the people' had, as a result of many kinds of movements and struggles, been enlarged to include virtually all adults—men and women, workers and property holders, peasants and landlords. This was true regardless of the form of the state; however authoritarian a government might be its electoral base was conceived to be the entire adult population. The newly established countries of Asia generally provided for universal suffrage in their constitutions. There still remained large areas of the world where the political structure did not rest even in theory on the majority of the people, notably in the Union of South Africa where the African and Coloured peoples were excluded from political participation, in parts of tropical Africa still under colonial rule and in some theocratic states of the Islamic Middle East. But the vast majority of the world's populations enjoyed more political rights than at any time in the world's history.

Not only were political rights extended, but the state took note of all elements in the population. In 1900 only a few countries had an accurate census of their populations; still fewer kept records of their people's illnesses and causes of death, their occupations and employment, their education and

housing, their marital status and incomes. At mid-century most governments compiled such data from year to year or decade to decade, as a guide for national policies and as a basis for observing the results of policy in terms of the total population. Even where indigenous populations within the borders of the state still lived a tribal or otherwise isolated life apart from the general society—in South and Central America, the United States, the USSR, China, India, New Zealand, Australia—governments declared the welfare of these enclaves to be a state responsibility and took steps to make them more fully a part of the body politic.

Even more distinctive of the twentieth century was the increased scope of the state's activity. The liberal democratic state of the nineteenth century interfered as little as possible in the affairs of the people and left the individual free to go his own way so long as he did not endanger the state or engage in activities contrary to law and accepted ethics. The state was not expected to assume direct responsibility for promoting the welfare of its citizens beyond the relief of paupers, measures to check epidemics, and such education as might be required to enable people to perform their duties as citizens. As late as the first decade of the twentieth century some outstanding students of political theory in Britain regarded the introduction of social insurance in that country as the beginning of the end of democracy.

The modern state, however, ceased to be merely a bystander while its citizens pursued their several interests. It provided public utilities, medical services and social insurance; it recognized housing as a national concern; it used taxation as an equitable method of providing for national welfare and fiscal and monetary policy to promote full employment. The mounting requirements of industrial society and the concept of the state as including all the people thus changed the state's functions, its responsibilities and its direct activities.

These trends were present in all twentieth-century states regardless of their form, their history and the stage of their economic development. Although countries which had gone furthest along the road of public responsibility for the people's welfare, such as the Scandinavian countries or the USSR, were poles apart from those at the other extreme which had hardly made a beginning, such as Saudi Arabia or Yemen, the general direction of development was the same. Even where there was active resistance to widening the basis of participation, as in the Union of South Africa, the scope and functions of the state were enlarged and the state undertook in some measure to serve the total population.

The issue in the twentieth century was thus not whether or not the state should enlarge its scope and reach all the people. The two issues which produced revolution, war and terror and which at mid-century still divided the world into competing camps were: what should be the state's form and, in extending its activities to reach all the people, was it primarily as their servant or as their master.

II. EXTENSION OF LIBERAL DEMOCRACY BEFORE THE FIRST WORLD WAR

At the opening of the century, liberal democracy was widely accepted in principle throughout the western world as the norm toward which societies were tending. In practice popular sovereignty was far from a reality, for not only restricted suffrage but lack of economic security and education made it ineffective. Autocracies remained in many parts of the world but, in the optimistic view of the liberal thinkers of the West, these were assumed to be the relics of an unenlightened past, as in China, Turkey or Russia, or they were regarded as deviations from the norm, as in Latin American countries where dictators from time to time seized the government of states with democratic constitutions.

To say that liberal democracy was the accepted norm of the West is not to deny that the existing autocracies were prepared to resist with utmost rigour efforts to bring this principle to their realms; the ruthlessness with which the Russian tsar put down the revolutionists in 1905 bore ample testimony. Nor is it to ignore the anomaly of autocratic colonial rule imposed on subject peoples by states which were among the leading exponents and practitioners of liberal democracy at home—Great Britain, France, the Netherlands.

But in spite of these factual situations few in the West were prepared seriously to challenge liberal democracy in principle. In a guide for newspaper readers and debaters published in 1903 by John Bertram Askew, neither democracy nor dictatorship appeared on a list of some 250 controversial topics. The only related questions listed were whether or not members of parliament should be paid, whether parliaments should be shorter, and questions involving freedom of speech and opinion, religious equality and how much honour should be paid to the intellectual professions. A few voices were raised to accuse democracy of cultivating mediocrity, of creating a servile state and of being incapable of decisive action, but these were individual dissenters and not yet part of a critical chorus.

1. *Broadening base of liberal democratic states*

As a dynamic principle, both within states where it was the prevailing form and in its spread to other areas where it was not traditional, liberal democracy had two facets, liberty and equality. Liberal democracy of the nineteenth century stressed liberty—the freedom to think and speak, to assemble and worship, to engage in free enterprise for economic gain. The state was conceived as an instrument which should create the conditions for the pursuit and enjoyment of freedom. In theory this was freedom for all, within the limits of the infringement of the freedom of others, and in this sense it was egalitarian. But in practice the inequalities of society, in access to wealth, to education, to the means of expression, often limited or even negated freedom.

In the late nineteenth and especially in the early twentieth century, a growing recognition that the reality of democracy was bound up with a closer approach to the ideal of equality was reflected in a mounting tendency to broaden democracy's base. In its most general and obvious form this trend involved extending the franchise, first to males who lacked property and then to women. Equally important was the trade union movement and the accompanying extension of labour influence into the political field. The trade unions played a major part in reducing the disparity of status between workers and other segments of the population.

The organization of labour was not achieved without a bitter struggle during which its opponents appealed to the principle of individual freedom against the efforts of workers to achieve equality of bargaining strength through collective action. But gradually what had been regarded as a conspiracy in restraint of trade came to be tolerated in principle as a legitimate form of voluntary association, then protected in its right to function and its members assured by law of their right to join without intimidation by employers. By the middle of the twentieth century the trade union had become a recognized, integral part of a modern liberal democratic state.

The trade union movement was only the most important of the many tendencies to broaden the base of democracy in traditionally democratic countries and to reduce inequality during these years. Movements to increase the participation of women in national life, through enlarged opportunities for education and employment as well as suffrage, reduced the disparity of status between men and women. Efforts were also made to extend equality of rights and opportunities to such disadvantaged elements in the population as Negroes or Jews or religious or national minorities. These movements gained momentum over the years, but in the early decades of the century they were already in the process of converting states which had been mainly the expression of the propertied males of the dominant ethnic element into more nearly comprehensive and egalitarian democratic societies.

The extension of government activity to include social insurance, labour legislation and health and welfare services was a reflection of this change. For these measures served the interest of the broadened electorate as the interests of the middle-class electorate had been served by the former system of *laissez-faire.* Although it was not until the second quarter of the century that the concept of the welfare state as an expression of liberal democratic principles emerged clearly, the trend was present and the first elements of policy already initiated before the first world war. The war itself accelerated the trend, for the improved conditions achieved or promised during the conflict were at least partially retained or secured thereafter; the American war slogan 'to make the world safe for democracy' made the doctrine of equality more popular in Europe; the post-war collapse of some European currencies and the decline of others destroyed or reduced much inherited wealth.[1, 2, 3, 4]

The economic crisis of 1929–33 gave an added impetus to the consolidation of the role of the state and the extension of its functions as governments intervened more and more deeply in economic life in the effort to revive their depressed economies and to reinstate their unemployed people. Finally, during the second world war, all the belligerent countries assumed direct controls over many aspects of national life and generally retained some features of these controls when the war was over.

In the countries which had been formed by European settlement overseas, where feudal institutions and rigid class structures had never existed—the United States and Canada, New Zealand and Australia—liberal democracy was taken more completely for granted than in older societies, and the broadening of its base came earlier and more thoroughly than where older institutions hung on. Manhood suffrage had prevailed throughout most of the United States from the early nineteenth century and universal public education was well established in most sections before the middle of the century; Negroes, however, were still effectively excluded from the polls in some states during the twentieth century in spite of national law, and women only secured the vote on a national scale in 1920. New Zealand and Australia were in the vanguard in many types of social legislation.

2. *Spread of liberal democracy to new areas*

In the first decade of the twentieth century liberal democracy became the ideal of the rising *bourgeoisies* in eastern Europe, the Middle East and parts of Asia and the inspiration for movements of reform. Universal manhood suffrage was introduced into parts of Austria-Hungary in the first decade of the century, but the Hapsburg empire was a long way from the pattern of the parliamentary democracies of western Europe. Within the autocracies of Russia, Turkey, Persia and China, and in imperial Japan, revolutionary or reform movements attempted to achieve the beginnings of democracy.

In Russia the *bourgeoisie* in 1905 demanded from the tsar constitutional reforms and guarantees of civil rights, and they were joined by a general strike of Moscow workers and by revolts of peasants seeking to eliminate the hold of landlords. The 1908 revolution of Young Turks was carried out under the banner of 'liberty, equality, fraternity and justice' by a combination of young Turkish emigrants in Paris and a Committee for Unity and Progress composed of discontented officers and freemasons in Turkish towns.[5]

Inspired by the Russian and Turkish efforts, young Persian intellectuals with western education led a movement in the same year which, with some British backing, was successful in forcing a quasi-liberal constitution on the shah; the parliamentary body set up in response to this movement survived through the vicissitudes of the following fifty years.[6]

Japan had adopted parliamentary forms along with other western institutions after the Meiji restoration in 1868, but the franchise was extremely restricted and the retention of many of the strongly feudal features of Japanese

society had kept parliamentary processes from becoming more than superficial phenomena. Within Japan, however, repeated reform movements sought to modify the feudal structure and to give the forms of political democracy some reality. Even the dowager empress of China found it necessary to concede constitutional reforms in 1905, but these came too slowly to check the revolutionary movement led by Sun Yat-sen which converted China into a republic in 1911 with institutions which attempted to embody the kind of liberal democracy which Sun had learned in the West.

None of these movements resulted in the establishment of effective liberal democratic states, but they reflected the extent to which the principles had spread and had become the ideal in terms of which discontent with autocratic rule or status in world affairs expressed itself.

These same ideals also penetrated colonial areas. This was most notable in India which had the longest and most thorough exposure to British parliamentary thought and institutions, and possessed a considerable middle class, but it occurred to some degree wherever western-trained elements began to seek leadership in colonial areas. Such ideals could not find expression in the years before the first world war, but the fact that they had been assimilated and engrained in the aspirations of the colonial leaders became evident a generation later when the peoples gained their independence and made these ideals the basis of the constitutional systems of their states.

III. CHALLENGES TO LIBERAL DEMOCRACY IN THE INTER-WAR YEARS

During the inter-war years liberal democracy of the western type was challenged in theory and in practice both from the right and from the left, both from fascism and from the revolutionary communist movement, and it was subjected to sharp attacks from critics within its own ranks who raised doubts about its premises, criticized its practices and expressed fear of its impact. The few voices in western Europe which had been heard to question democracy or deny its goals in the early years of the century became a chorus by the 1930s. They were even joined by some few voices from Britain, and some from the United States where democracy was taken for granted, who feared the masses as a downward-levelling force or assailed democracy as the worship of incompetence. The economic depression of the 1930s offered an added cause for losing confidence in a political system which appeared unable to cope with economic decline.

The many dictatorships which gained power in eastern Europe, the Balkans, the Iberian peninsula and parts of Latin America during these years were evidence that, under the conditions of the period, liberal democracy had insufficient vitality in the areas where it lacked strong roots to organize new states successfully or to sustain the reforms which it achieved in others. They did not, however, offer a new ideological challenge. They were essentially feudal or military dictatorships, sometimes reinforced by clerical support as

in Spain, Portugal and Austria, and they represented the old pattern of resistance to the democratization of feudal societies.

1. *The challenge of fascism*

More serious was the challenge of fascism which struck at the basic assumptions and values of democracy, not merely at its institutional forms. Liberal democracy rested on an acceptance of the essential worth and dignity of the individual, whose welfare was the *raison d'être* of the state; by definition, the state was his servant, not his master. It assumed that men were rational and could act responsibly so that the state might be entrusted to their judgment. The institutions characteristic of democracy were implicit in these assumptions and values—legal guarantees of certain individual rights against arbitrary action by other individuals or by the state itself, including the right to hold and express opinions and to form voluntary groups such as political parties for such purpose; acceptance by the minority of majority rule and respect by the majority for minority rights.

Fascism denied these basic assumptions about man—his rationality, his potentiality for responsible action and his basic value as an individual. It denied that the essential purpose of the state was to secure the freedom and welfare of the individual and asserted the value of the state as an end in itself. Far from trusting the judgment and capacity of the people, fascism exalted the leadership principle and made irrational loyalty a substitute for rational choice. On these premises, the fascist states scorned and suppressed democratic institutions—parliamentary forms, party organization as a means of expressing diversity of opinion, and all the personal freedoms which the liberal states guaranteed.

The challenge from the fascist, national socialist and other dictatorships in the inter-war years placed liberal democracy on the defensive. Obvious weaknesses in the parliamentary systems of some countries, such as the instability of the parliamentary régime in France, lent colour to the attacks on parliamentary principles as such. These weaknesses were not characteristic of the countries where democratic processes were rooted in a long experience of voluntary civic activity and responsible local government. They appeared in areas where parliamentary institutions had been superimposed on an administrative structure, as in France, or on feudal localism as in Italy, or on clerical dominance as in Spain and Austria, or on paternalistic authoritarianism as in Germany.

The requirements of modern warfare had forced a great extension of state power during the war and had offered an example to those who would make a principle of the paramount authority of the state and the subordination to it of the individual citizen. The growth of economic power in the hands of great corporations made the nineteenth-century image of free enterprise and competitive individualism obviously false, and the democratic states found themselves forced to regulate many aspects of economic life. The imperatives

of modern industrial society seemed to call for principles of integration rather than of individualism and competition, and its highly technical and complex character required a more sophisticated form of administration and a more technically competent bureaucracy than had been implied by the ideal of the *laissez-faire* state. In addition, modern techniques of communication placed immense power in the hands of those who controlled the mass media and the means of mass propaganda—power which the state might use or might have to control.

Although the dictatorships differed as between those which were merely dictatorial in practice, such as those of Marshal Pilsudski in Poland, King Alexander in Yugoslavia and traditional dictators in parts of Latin America, and those which made a principle of the fascist alternative to democracy, they had certain features in common. All discarded or repressed parliamentary institutions and the party system on which they rested and substituted a single party; all limited freedom of speech and discussion and brought most or all organizations and institutions into a common pattern; all were anti-individualist and in one way or another substituted corporate entities for the individualism of old-style democracy, although only fascist Italy, clerico-fascist Austria and Portugal specifically sought to create something like a corporate state.

Pro-fascist elements who challenged democracy from the right were able to take advantage of the liberal democracies' fear of the opposite challenge from the left. In one state after another dictators rose to power claiming to be defenders of the nation against the menace of revolutionary socialism or communism.

2. *The challenge of communism*[7]

The basis for the attack on liberal democracy from the left differed fundamentally from that of the right, though the challenge was no less sharp and the methods employed, both to destroy democracy and to govern in its place, had certain features in common.

In challenging liberal democracy, the communists accepted many of the fundamental assumptions that fascism denied. They, too, viewed man as a rational being whose judgment in the long run could theoretically be trusted, and they regarded the state as the product of rational action, not as a mystical entity. The charge against liberal democracy was that it was not in reality democratic. The *bourgeois* capitalist state, in this view, was incompatible with the welfare of the people to which it gave lip service, for the liberty which it cherished was only the liberty of those who owned the means of production to exploit those who did not. In the Marxian view, state power was always exercised solely by that part of society which owned the instruments and means of production.

Liberal democracy in theory took no account of class as a phenomenon. In practice it functioned in European societies which were strongly stratified

along class lines and in North America and Oceania where class structures, though far less rigid and historically engrained than in Europe, were nevertheless real. In societies which were still feudal and authoritarian the class division was even sharper. The socialist challenge stressed class as the major social reality and accused liberal democracy of being in fact only a cloak for the dominance of the *bourgeoisie*.

Communism differed from liberal democracy in its view of the individual's relation to society. Unity of social and individual interests was a central concept according to which the individual, as a cell in the organism that is society, derives his rights from the society and realizes his purpose and his individual development in service to it.

The party system also differed fundamentally from that of the liberal democracies. Whereas in the liberal democratic states political parties were the means of organizing and expressing the differences of opinion and interest presumed to exist, the Communist party considered itself the vanguard and instrument of the working people in a state where differences were being eliminated with the elimination of class. It was a select, trained and disciplined body which carried responsibility for the interests of the proletariat. The Communist party was thus the central organization, the leading and guiding force within the state.

In the operation of the communist state all organs of state power constituted a single system conforming to the principle of democratic centralism as formulated by Lenin, i.e. the principle of elective organs and the subordination of lower organs to higher ones. The system was conceived as permitting the power over state matters to be concentrated in the hands of a central authority while encouraging maximum initiative of the population.

The various organs of state and party, and of such other bodies as trade unions and women's and youth organizations, were elected by universal suffrage, generally from lists which the voters could accept or reject rather than by choice among competing candidates. Active discussion of matters referred by higher organs enabled the lower units to understand and help to carry out central decisions and provided the central organs of the party and state with reflections of popular opinion which they could take into account in arriving at decisions. In the USSR a million or more people came to serve as deputies in organs of state power and millions of citizens were members of regular committees of the Soviets. In 1957 an estimated 40,000,000 took part in discussions of the draft law for the reorganization of industrial and building management.

In Marxist-Leninist theory the dictatorship of the proletariat was conceived as a temporary device for transferring power from the dominant *bourgeois* class to the proletariat and eliminating the *bourgeoisie*. The ultimate objective was the creation of a classless society which should, finally, no longer require a strong, dictating state. According to this view the state would eventually 'wither away', for as all citizens would be drawn into the manage-

ment of economic and cultural affairs, functions performed by state organs would be gradually taken over by social organizations and in the ultimate communist society there would no longer be any need for organs for the government of people, only for the government of things, i.e. the economy. The history of the first forty years of communist rule in the Soviet Union was marked by Stalin's dictatorial power, but after his death in 1953 the Soviet Communist party condemned the policy of mass repression. From 1957 on, a number of central state functions were decentralized, but the state continued to be the main instrument of social change and the party kept its leading role.

The concept that the state is a temporary phenomenon, that the party is a leading and guiding group rather than an all-inclusive body to which all must belong, and that there should be active social participation, distinguished the communist concept of the state sharply from the fascist concept of the state as a mystic entity embodying the leadership principle. Yet though these systems were based on opposing political and socio-economic principles both were, in theory and in practice, fundamentally at variance with the principles and practices of liberal democracy.[8]

IV. LIBERAL DEMOCRACY AND DICTATORSHIP AT MID-CENTURY

Though challenged from both right and left, and the object of many doubts and questions expressed from within, liberal democracy at the middle of the twentieth century retained a strong position in the world and democratic principles maintained their appeal. Liberal democracy held its ground and prospered in its old strongholds—in the British Isles and the United States, in Canada and the Scandinavian countries, in the Low Countries and Switzerland, in Australia and New Zealand. It stood firm in principle even where it was breached in practice, notably in Latin America where although dictatorships continued to rise, democratic principles continually reasserted themselves in one country after another when they had been temporarily lost.

Liberal democratic principles provided the basis for the constitutions of most of the new states created after the second world war by formerly colonial or subject peoples. But the application of such principles under the historic conditions of liberation was far from simple. Institutional forms inherited from colonial powers had evolved under the conditions of the home country and were not necessarily suited to the needs of former colonial states. In fact some principles and institutions were directly at variance with the cultural traditions of the areas.

Except in the communal village structures of some areas, democracy as a functioning process was almost unknown outside India and Pakistan where some local machinery based on elective principles had been in operation. More fundamentally, the principle of democratic obedience to majority decision was an alien concept. Furthermore, the difficulties of adapting

democratic systems inherited from colonial powers were complicated by the particular forms of such institutions. In Indonesia the multi-party system with an elaborate method of proportional representation inherited from the Dutch produced no less than fourteen contenders for the vote of the inexperienced Indonesian citizen in the country's first national election in 1956. The British two-party system had the virtue of simplicity, but it depended on the willingness of the defeated minority to function as a loyal opposition instead of defying the authority of the state.

The new states, moreover, came into existence at a time when governments of all types carried far greater responsibilities than those which older democratic governments had faced in their early stages. Their efforts to achieve rapid economic and social development intensified these responsibilities, and gave rise to doubts as to whether the methods of liberal democracy were adequate to the tasks. Indonesia's president, Sukarno, for example, sought a formula for what he called 'guided democracy' in the effort to provide some of the positive direction he observed in communist countries without resort to dictatorship. A decade after their creation the newly independent states, with the possible exception of India, were far from having made a working reality of the democratic principles which their constitutions professed. In fact many of the original democratic constitutions were superseded or set aside in favour of some form of central authority designed to facilitate positive, immediate action and to permit the development of new political forms adapted to the needs and traditions of each area.

Everywhere there was a tendency for democratic states to take on the characteristics of a welfare state and to incorporate a measure of what was originally projected as part of the socialist ideal and came to be loosely called socialism. In the new and the revised constitutions adopted in the decade following the second world war by more than thirty countries outside the communist areas, responsibility of the state for many aspects of health, education and welfare were specifically set forth as obligations of the state. Socialism, which had originally been offered as a challenge to and basic criticism of liberal democracy, was in a large measure incorporated into the practice of the democratic states. Acceptance of the principle varied markedly from country to country, and difference in practice did not necessarily coincide with difference in professed policy. Socialism might be loudly denounced while much of the actuality was being adopted, or loudly proclaimed but haltingly applied. In spite of the fact that India's announced policy was to develop a 'socialist pattern of society' while the United States preached 'free enterprise' and opposed 'socialism', a far larger proportion of the national income was spent through government channels in the United States and a much wider range of services was publicly provided than was the case in India during these years.

In the years after the second world war what might be termed old style dictatorships continued, for example, in the Iberian peninsula and in

certain of the Latin American republics, where some dictators fell, some rose and others retained long established control. These pragmatic dictators based their rise on military force and maintained their position essentially by that means. They offered no ideological justification for seeking power, beyond the maintenance of the *status quo*. They were generally thrown from power by military means. In the course of these years the tendency was for their number to decline, but some very tough ones survived and there was no assurance that others would not gain power.

The principal fascist dictators, who had appealed not merely to force but to an alternative political ideal, went down to defeat and destruction in the second world war. Democratic forms were installed by the victorious powers in West Germany and Japan, and continued after the withdrawal of occupying forces. Italy restored the parliamentary system which Mussolini had destroyed. But in Argentina Juan Perón established a fascist government in 1943 and tried to organize fascist movements in other parts of the South American continent until he was ousted in 1955. The Nationalist party which came to power in the Union of South Africa in 1948 adopted some of the Nazi principles and techniques. A decade after the death of Hitler and Mussolini there was still no guarantee that their doctrines might not be reborn and their methods applied again.

Communism, meantime, scored signal successes and showed great vitality. The effective industrialization of the Soviet Union gave it great appeal in underdeveloped areas seeking to remake their societies at a rapid rate. In the post-war years it gained control of eastern Europe, spread to China and organized a third of the population of the world. Politically, its success in the Soviet Union was achieved not by emphasizing the features common to or closely related to liberal democracy but by those most at variance. Soviet dictatorship under the leadership of Joseph Stalin did not hesitate to restrain by vigorous action any attempt to oppose party leadership. By purges against politicians, engineers or generals he eliminated all deviation from the party line. Stalin's successors acted in a much more lenient and flexible but no less effective way. Similar methods were also adopted by the Chinese communist state.

Yugoslavia alone among the communist states deviated from the Soviet pattern of democratic centralism, choosing to isolate itself from the international communist movement, and experimenting with more decentralization, though still retaining strict party control.

Modern states, whatever their form, extended their functions to meet the needs of industrial society and to involve, in some way, the total population. As they expanded their functions all types developed extensive bureaucracies, which in turn became major elements in their societies. All governments, moreover, had at their disposal the new means of mass communication, with the vast powers to reach and influence people which these afforded. In the course of the twentieth century the modern state, whatever its political form, thus became an increasingly dominant factor in the life of mankind.

NOTES TO CHAPTER III

1. Some scholars in the liberal tradition of the West criticize the text for failing to discuss the extension of state activity as a threat to freedom. Professor Wilhelm Röpke writes: 'It is hardly scientific to write on social services without mentioning that the welfare state is a very serious problem, economically, politically and morally and far from being a "progress" under all circumstances.'

Those who look with greatest distrust on the welfare state fear that it will destroy freedom and lead to totalitarianism. They distrust the effects of the expansion of the functions of the state, and they correlate the loss of economic individualism with the loss of political, social and intellectual freedom. They refuse to believe that the state, as envisaged by the proponents of the welfare state, can act as a 'positive economic force' (J. M. Clark) or as a means of 'ensuring the general welfare of all its members' (Kenneth Boulding). Instead, they prophesy that if the trend toward the welfare state continues, western civilization is doomed to follow 'the road to serfdom' (F. A. von Hayek).

At the other extreme are scholars, of whom J. K. Galbraith in *The Affluent Society* (Boston, 1958) is one, who attack the failure to canalize a larger share of national wealth through government, and who contrast the low level of spending and inadequate standards for public services with the high level of mass spending and the abundance of goods in the private sector of modern capitalistic economies.

A majority of scholars and of policy makers probably take an intermediate position in the matter, accepting the principle of using the state as an instrument to achieve common welfare objectives but remaining concerned about the question of how to acquire the benefits of expansion of governmental activity while avoiding disadvantages. They believe that the welfare state has become essential, that it has developed necessary services and institutions, and that it is approved and desired by the masses, not merely in advanced industrial countries but in countries struggling to build a modern economy and society. They consider it essential to preserve individual responsibility and initiative and are therefore alert to safeguard individual rights and to keep governmental activity within the bounds of the clearly essential. Even in the Scandinavian countries, where the concept of the welfare state is thoroughly accepted, there is a lively issue of public policy as to how far state-directed activity should go—beyond the minima already established—in making available to all citizens benefits commensurate with the nation's wealth.

Among other works on the subject, Professor E. N. Anderson suggests the following:

Kenneth E. Boulding, *Principles of Economic Policy* (New York, 1958).
Colin Clark, *Welfare and Taxation* (Oxford, 1954).
John Maurice Clark, *Economic Institutions and Human Welfare* (New York, 1957).
Sheldom Glueck (ed.), *The Welfare State and National Welfare. A Symposium on Some of the Threatening Tendencies of Our Time* (Cambridge, Mass., 1952).
Frederick A. von Hayek, *The Road to Serfdom* (Chicago, 1956).
Frederick A. von Hayek, *The Constitution of Liberty* (Chicago, 1960).
Bertrand de Jouvenal, *The Ethics of Redistribution* (Cambridge, 1951).
I. M. D. Little, *Critique of Welfare Economics* (New York, 1957).
Alan T. Peacock (ed.), *Income Redistribution and Public Policy* (London, 1954).
Wallace P. Peterson, *The Welfare State in France* (Lincoln, 1960).
Wilhelm Röpke, *A Humane Economy: the Social Framework of the Free Market* (2nd ed., Chicago, 1961).
Richard Titmuss, *Essays on the Welfare State* (London, 1959).

2. Candidate of Juridical Sciences V. Tumanov notes:

(1) Advocates of the theory of the 'welfare state' hold that in the western states economic policy is directed towards raising the standard of living of the population as a whole and liquidating abuses by the monopolies through their subjection to controls. However, the facts show another thing: in 1950–51, for example, the US government handed over to the monopolies for exploitation 278 industrial enterprises built up during World War II at the taxpayers' expense. The thesis that the State 're-distributes' the national income in favour of broad segments of the population, in the first instance through the medium of fiscal policy, does not correspond to the facts either. Between 1949 and 1960 the

amount of income tax paid in the USA increased by more than double, from 17·9 to 38·6 milliard dollars, and the social insurance tax by three and a half times, from 2,477 to 8,644 million dollars. (See *Economic Almanac*, 1960, p. 426.)

Many sociologists hold that the first task of the welfare state is to liquidate unemployment (see, for example, R. M. Titmuss, *Essays on the Welfare State*, London, 1959). However, the western states of to-day are incapable of dealing with this problem. According to official statistics in 1961, there were about 8 million unemployed each month in the USA, Canada, Great Britain, France, Western Germany, Italy, and Japan—most of them in the United States (see *Monthly Bulletin of Statistics*, U.N., February 1962). With regard to the social services rendered by the 'welfare state' (unemployment assistance, social insurance, etc.), it is worth quoting the words of the British sociologist Crossland, one of the defenders of the 'welfare state' theory, who was compelled to admit that, 'at the present time the working class pays more in taxes than it receives in the form of social expenditure' (C. R. Crossland, *The Future of Socialism*, London, 1957, p. 44).

(2) It is undeniable that in a number of 'liberal democratic' states during the twentieth century there has been a certain extension of the voting rights enjoyed by the citizens of these countries. However, formal universal suffrage is in practice restricted by various kinds of qualifications and restrictions. (See Note 10 to Chapter XXIII.)

3. *On the question of the welfare state, the Author-Editors write:*

'As we have noted in the Preface, we have used the term "welfare state" to indicate a general concept of the role of the state as a positive instrument to promote the welfare of its citizens. The development of this concept, and the wide range of actions growing out of it, is an important phenomenon of the twentieth century. We have chosen to discuss it using the term which is widely current, without implying the realization of any specific actuality in respect to state benefits or services. We recognize that the term "welfare state" could be given a very precise meaning, such as that offered by V. A. Tumanov ("Le Welfare State. Est-il un mythe ou une réalité?", Journal of World History, *VII, 1 (1962), p. 224), i.e. a state in which all citizens are entitled to receive the benefits (Mr Tumanov says the "necessities") made possible by the level of public wealth. If we had accepted such a limited definition, we should have had to seek some less familiar term with which to discuss the great extension of public services and the acceptance by the state of responsibilities not regarded as within its function in previous centuries.'*

4. *In regard to unemployment in capitalist countries, the Author-Editors draw attention to the following table which shows the wide difference among capitalist countries in the extent of unemployment during the period 1954–60. It includes the countries for which the United Nations could compile reasonably comparable data, although the footnotes to the table indicate that even these data differ considerably in source and therefore in meaning. No comparable figures are available for any of the communist countries except Yugoslavia, since these countries state that full employment is provided under their systems.*

UNEMPLOYMENT, 1954–1960

(Percentage Unemployed)

	Austria	*Belgium*[1]	*Canada*	*Denmark*	*Germany*[2] *Fed. Rep.*	*Ireland*[3]	*Italy*[4]	*Japan*
1954	7·9	10·9	4·6	8·0	7·0	8·1	10·0	1·5
1955	5·7	8·4	4 4	9·7	5·1	6·8	9·8	1·6
1956	5·4	7·0	3·4	11·1	4·0	7·7	9·9	1·5
1957	4·9	5·5	4·6	10·2	3·4	9·2	9·0	1·2
1958	5·3	8·5	7·1	9·6	3·5	8·6	9·0	1·3
1959	4·8	9·5	6·0	6·1	2·4	8·0	8·7	1·3
1960	3·7	7·5	7·0	4·3	1·2	6·7	7·9	1·0

	Netherlands[5]	*Norway*	*Puerto Rico*	*Sweden*[6]	*UK*	*USA*[7]	*Yugoslavia*
1954	*1·9*	*1·3*	*15·4*	*2·6*	*1·5*	*5·6*	*3·3*
1955	*1·3*	*1·2*	*14·3*	*2·5*	*1·2*	*4·4*	*2·7*
1956	*0·9*	*1·4*	*13·0*	*1·7*	*1·3*	*4·2*	*3·9*
1957	*1·2*	*1·4*	*13·0*	*1·9*	*1·6*	*4·3*	*4·3*
1958	*2·3*	*2·3*	*13·9*	*2·5*	*2·2*	*6·8*	*5·9*
1959	*1·8*	*2·2*	*13·8*	*2·0*	*2·3*	*5·5*	*6·7*
1960	*1·2*	*1·7*	*11·5*	*1·4*	*1·7*	*5·6*	*6·1*

This series (from the International Labour Office) generally represents the total number of persons wholly unemployed and temporarily laid-off and is derived from unemployment insurance statistics, employment office statistics, or from sample surveys of the labour force. In using this series, consideration should be given to the source of the data. In general, the figures relating to percentage unemployed are calculated by expressing the number of unemployed in a given period as a percentage of the total number of employed and unemployed persons in the group considered during the same period.

(*1*) *Including persons partially unemployed.*
(*2*) *Unemployment among insured members of trade union funds.*
(*3*) *Excluding agriculture, fishing and private domestic service.*
(*4*) *Percentages relate to economically active population (1951 population census).*
(*5*) *Excluding persons employed on public relief work.*
(*6*) *Prior to 1956, trade union statistics, excluding commercial workers; beginning 1956, unemployment among members of unemployment insurance funds.*
(*7*) *Prior to 1956, excluding Alaska and Hawaii.*

Source: United Nations, Monthly Bulletin of Statistics, *February, 1962.*

Doctor of Historical Sciences E. D. Chermensky stresses that the Russian revolution of 1905–7 was the first people's revolution of the imperialist epoch. It faced the task of overthrowing autocracy and destroying the relics of serfdom which permeated every sphere of economic and social life. . . . The economic basis for all these feudal relics was the ownership of land by the nobility. For this reason the agrarian question, i.e. the struggle by the peasants to liquidate the landed estates, was the principal feature of the bourgeois-democratic revolution in Russia. The Russian revolution was bourgeois-democratic according to its objective content, but it differed radically from the bourgeois revolutions of the seventeenth, eighteenth, and nineteenth centuries, which took place at a time when capitalism was in the ascendant and the bourgeoisie was still a revolutionary class. The revolution of 1905–7 took place in the epoch of imperialism, the development of which is characterized by the decay of the capitalist system and the intensification of social and political contradictions of every kind. By the beginning of the twentieth century the Russian working class had not only emerged as an independent social group, a class separate from the common mass of toilers, but had already acquired a considerable experience of class struggle, had created its own Marxist party and was acting as the most advanced and well organized political force in the country. . . . The Russian bourgeoisie, alarmed at the scope of the labour movement and bound by a multitude of ties to the reactionary landlords and to tsarism, was afraid of the democratic revolution. This resulted in the emergence, in the historical conditions of Russia, of a paradoxical situation, which V. I. Lenin described as follows: 'The victory of the bourgeois revolution in this country is impossible as *the victory of the bourgeoisie*. . . . The prevalence of a peasant population, with the heavy bondage imposed on it by large-scale land ownership of a semi-serf nature, the strength and consciousness of the proletariat, already organized in a socialist party—all these events lent a *specific* character to *our* bourgeois revolution.' (V. I. Lenin, *Collected Works*, 4th Russ. Ed., Vol. XV, p. 41.)

The specific character of the Russian bourgeois-democratic revolution consisted in the fact that its entire development, its scope and forms were determined by the struggle of the proletariat. Mass strikes—that characteristic proletarian form of struggle—played a major part in arousing the peasantry to the revolutionary struggle and in preparing the people's armed uprising against autocracy. That is why the leading role in the revolution

of 1905–7 was assumed by the working class, with the peasantry, which was vitally interested in the destruction of the survivals of serfdom, becoming its ally.

6. In the opinion of M. S. Ivanov, Doctor of Historical Sciences, the Persian revolution of 1905–11 took place under the direct influence of the Russian revolution of 1905–7, and not of the Young Turk revolution, which began in 1908. See note 4 to chapter I.

7. Candidate of Juridical Sciences V. A. Tumanov states that the first socialist state in history was established in Russia as a consequence of the Great October Socialist Revolution of 1917. As a result of the popular democratic revolutions that occurred during and after World War II a number of other new socialist states came into being in Europe and Asia. The 600 million strong Chinese people embarked upon the path of socialist development. Much earlier, and in different historical circumstances, the Mongolian People's Republic came into being. The rise of new socialist states in Europe and Asia resulted in socialism ceasing to be confined to a single country and becoming a world system. The socialist state is the political expression of the new socialist system of economy, based on public ownership of the instruments and means of production. In a socialist society the means of production are the property, not of the privileged classes, but of the entire people, and for this reason the state power also belongs to the people.

The development of the socialist state passes through two principal stages. The first of these coincides with the period of transition from capitalism to socialism. During this period there still remain relics of the classes which have been overthrown by the revolution. These remnants of the bourgeoisie and the landlords offer stubborn resistance to the gigantic efforts in the sphere of economic organization, cultural and educational work, and the diffusion of democracy to the broadest masses of the population, made by the proletarian power. Because of this, the task of crushing the resistance of the exploiting classes is one of the main functions of the socialist state.

All progressive revolutions have had to overcome resistance by the classes that they have thrust from power. The socialist revolution brings about the profoundest social transformations of all. For this reason it has to overcome particularly stubborn resistance, which is intensified by support from external forces (e.g. the intervention of foreign powers against the young Soviet state, the support given from abroad to the Kuomintang regime in China, etc.), which in alliance with the peasantry and the other sections of the toiling population, effects the political leadership, wages a struggle against the remnants of hostile elements and dismisses them from power. The socialist state of this period constitutes the dictatorship of the proletariat.

Once socialism has scored decisive victories in all spheres of public life, there begins the process of the transformation of the dictatorship of the proletariat into the state of the entire people—an organ that expresses the interests and will of the people as a whole. In the USSR this process began in the mid-1930s, when socialism had won decisive victories in the towns and in the countryside.

It was reflected in the 1936 Constitution, which consolidated the victory of socialism in the USSR by the further development of democratic forms. However, the threat of armed attack, and then the war, and also the errors committed during the period of the Stalin cult, acted as a substantial brake upon the process of rapid development. Nevertheless these factors could not prevent the development of socialist society and its political superstructure in accordance with the laws that govern such development. Once the final and complete victory of socialism (the first phase of communism) had been accomplished, and society went over to the building of communism on an extensive scale, the dictatorship of the proletariat had fulfilled its historic mission and had ceased to be necessary in the USSR so far as the tasks of internal development were concerned. The Soviet Union became a state of the entire people. This was reflected in the new programme of the Communist Party of the Soviet Union (1961).

Other socialist countries, which are at the stage of building a highly-developed socialist society (for example, the Czechoslovak Socialist Republic, the Bulgarian People's Republic, the Rumanian and Mongolian People's Republics) have already entered upon the process of the transformation of the dictatorship of the working class into the state of the entire people. The forms of the socialist state are such as to make a living reality of that most important democratic principle, the maximum involvement of broad masses of the

people in the administration of society and in government. This is accomplished, in the first place, by means of a fully democratic electoral system; in the second place, by drawing into the work of all state organs broad active elements of the population; and in the third place, by the consistent development of social control over the activity of all organs of government and officials.

In the countries of people's democracy the forms of political organization have differed in a number of ways from those in the land of the Soviets (e.g. existence of people's or patriotic fronts, a multi-party system, etc.)—the result of the particular historic conditions governing the establishment of socialist states in these countries. However, the basic features of the Soviet and People's Democratic forms of government are the same: in both cases the form of government is republican, ensuring a plenitude of power to popular representative organs; in both cases the organizational and legal principle governing the entire state structure is democratic centralism; in both cases the apparatus of the new state power developed as a result of the destruction of the old military-bureaucratic apparatus (although this process of destruction took a different course where historical circumstances were different), and in its composition and principles of activity contributes to the maximum realization of popular sovereignty. The territorial organization of the socialist states accords with the principle whereby the state apparatus is brought as close as possible to the population and production; in multi-national states the principle of socialist federalism has created all possible opportunities and prerequisites for the elimination of national oppression of any kind, and for the voluntary association of free and equal nations and peoples within the framework of a single state.

The fact that the socialist state is a state of the entire people finds reflection in the further democratization of the forms whereby the authority of the state is implemented. During the period of transition from socialism to the higher phase of communism the main trend of development, so far as the socialist state is concerned, is the far-reaching extension and perfectioning of socialist democracy, the active part taken by all citizens in administering the state and guiding economic and cultural construction, the improvement of the work of the state apparatus, and the strengthening of popular control over its activity. During this period an increasingly important role is played by the system of representative organs—the Soviets (increasing number of deputies, broadening of their powers, etc.). Broad segments of the population come to be associated with the work of the Soviets and the executive apparatus. Simultaneously a number of important functions are handed over from the state organs to public organizations. There takes place a growth of direct democracy, implying in particular the practice of placing the most important government measures and legislative proposals before the whole people for discussion. There is a further democratization of the structure and forms of activity of the state apparatus (the principle of periodical removal of officials from their posts, extension of the electoral principle, etc.). The citizens of the socialist state come to enjoy stronger material and juridical guarantees of their broad democratic rights and freedoms.

In the socialist state there exist numerous public organizations, powerful trade unions with extensive rights, organizations of women, young people and so on. Among these public organizations a central position is occupied by the Communist Party, which is the leading and directing force in the state. The basic principle underlying the activity of the Party is its link with the masses. The Party is the vanguard of the working people.

It is not essential that in a socialist state there should only be one party. Where class differentiations still remain, it is possible that several parties should exist (as in the German Democratic Republic, or the Chinese People's Republic).

One of the most important principles of the socialist system is the unity of public and private interests. This gives wide scope for the development of the individual, for the vigorous growth of science and art, and for creative personal initiative. The fundamental principle of socialism is 'from each according to his ability, to each according to his work'. Socialism is only the first phase of communism. When the principle of 'from each according to his ability, to each according to his needs' has been realized, there will be unlimited opportunities for the comprehensive development of the individual.

Scientific socialism does not regard the state as something permanent and unchanging. As socialist society effects the transition to communism the socialist state system gradually develops into communist public self-government. As democracy expands, and all citizens

are drawn into the administration of economic and cultural affairs, many functions that were previously performed by state organs gradually fall to the competence of public organizations.

Public functions analogous to those currently exercised by the state in the administration of economic and cultural matters will be preserved under communism, but will change their character and become perfected as society develops. Their nature and the means of realizing them will be different by comparison with the situation under socialism. The organs concerned with planning and accounting, with management of the economy and the development of culture, which at the present time are state organs, will lose their political character and will become organs of public self-government. Communist society will be a highly-organized community of working people. They will live in accordance with generally-accepted rules of communist conduct, the observance of which will have come to be felt by all men as necessary and customary.

8. The treatment of communism in this chapter has been criticized by several scholars on the ground that the Author-Editors have treated official communist ideology as if it were reality, have overrated the communist maintenance of many forms of democracy and have understimated what these scholars regard as the danger of the dictatorship of the proletariat and Lenin's formula for party leadership. Some of those expressing this view are Mrs B. R. Scharf (United Kingdom), Professor Hans Kohn (United States), and in more general terms Professor Coengeno Quinn (Pontifical Gregorian University) and Professor Robert Strausz-Hupé (United States).

CHAPTER IV

THE TRIUMPH OF INDUSTRIALISM

In the twentieth century industrialism became the dominant, moulding force in the countries of its origin; it spread into new areas and it offered a goal to which much of the world came to aspire.

By the opening of the century it had fundamentally modified the life of western Europe and the United States and was penetrating elsewhere. In the first half of the twentieth century it revealed its capacity to raise the levels of living of entire societies, to transform one aspect of life after another and remake patterns of occupations and social relations, to shrink the globe by its mastery over distance, to provide a basis for more terrible warfare than the world had ever imagined and to modify the nature and functions of the state.

I. PROCESS OF INDUSTRIALIZATION

Twentieth-century industrialism was both an extension of the factory system and commercial economy of the nineteenth century and a new growth whose dimensions, speed of development, scientific basis and phenomenal productivity made it a powerful, dynamic force. The essence of modern industry was its dependence on and interrelation with science and its mass-production character. It not only rested on a scientific base but its whole method was characterized by the same qualities of rationality, experimentation, systematic organization and acceptance of change which were the essentials of the scientific approach; and it supported scientific research as an essential part of its own development. By harnessing energy and converting it to productive labour it created the equivalent of 500 to 1,000 extra hands for each worker employed, and thus replaced an immense amount of grinding human toil and made the modern industrial worker enormously productive.

The inner dynamics of modern industry pressed constantly for expansion, drawing more and more workers into its orbit, seeking ever wider markets for its products, stimulating constant efforts to improve methods, reduce costs of production and apply available scientific knowledge and providing an impetus to continuing scientific research.

The growth of industry was responsible for great migrations of people: millions of European peasants who streamed across the Atlantic in the late nineteenth and early twentieth centuries to supply the insatiable demand of American industries for workers, and were still coming in large numbers to Canada and parts of South America in the mid-twentieth century; more millions who left their farms for mines and factories in their own or neigh-

bouring countries of Europe or within North America. Countless others became part of the expanding industrial population of the USSR or went out to Australia, or moved to Japanese cities, or migrated from China to Manchuria in one of the largest mass migrations in history.

As industrialism developed in the countries where it became dominant, it

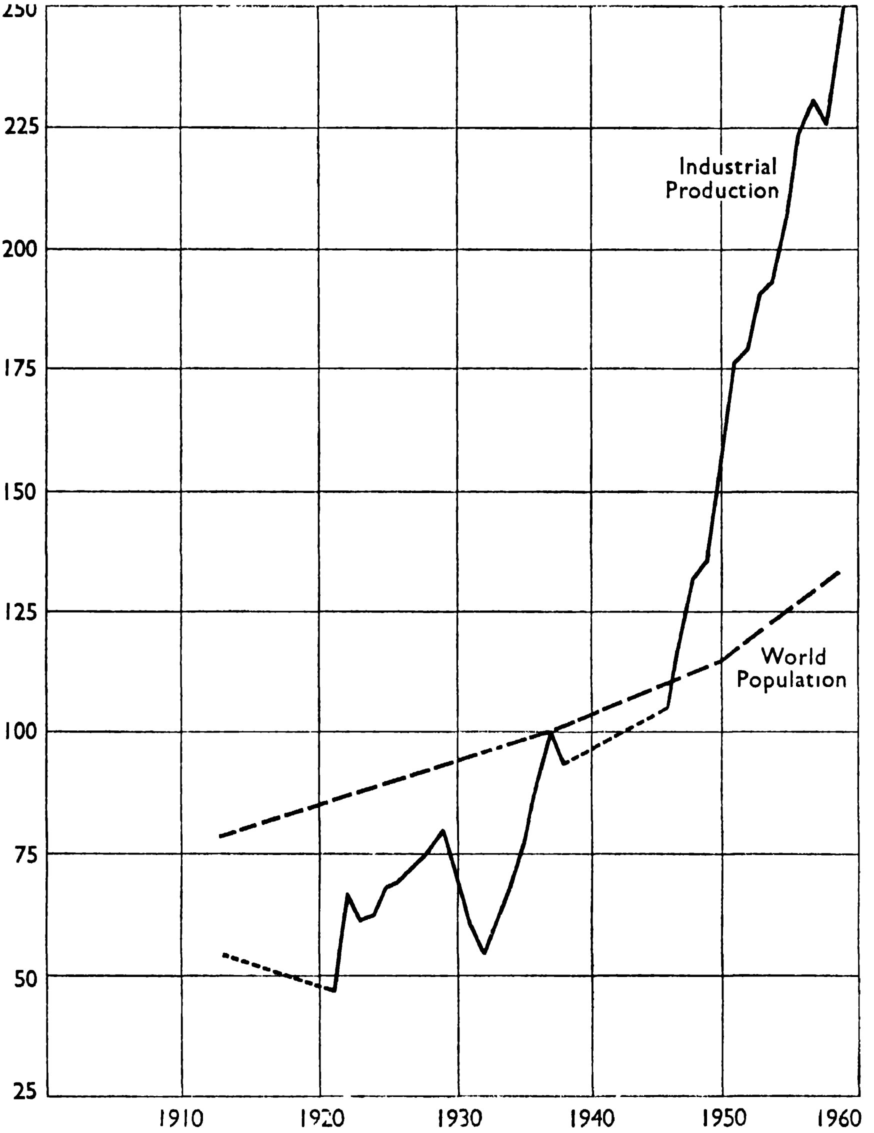


CHART II. World Industrial Production, 1913–59 (index: 1937=100).
Source: W. S. and E. S. Woytinsky, *World Population and Production*, 1953, p. 1002, and *U.N. Statistical Yearbook*, 1960.

ushered in a system of mass consumption which was as revolutionary in its impact as the factory system had been in the preceding century. For it meant a new pattern of life for masses of people and a reduction of the gulf which

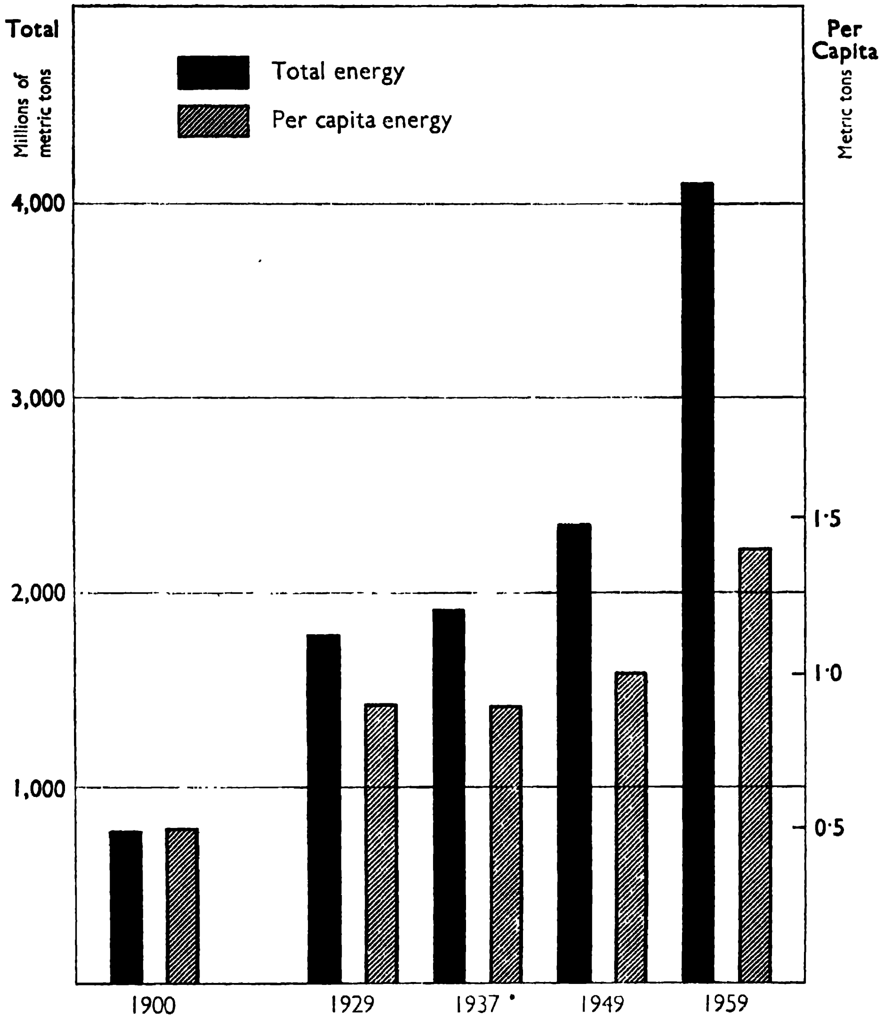


CHART III. World Production of Energy, 1900–59 (excluding work animals, wood, peat, bagasse, manure, etc., fuel).

Source: *U.N. Statistical Yearbook*, 1960, Table 120.

separated those who were able to enjoy the fruits of civilization and those who toiled to produce them. Mass production, which could not find its market in a limited class of the rich, forced the spread of material benefits to a wide segment of the population.

The main output of the most industrially developed countries was for their home market and most of the products which their people consumed were produced within the area. Countries differed in the degree to which they were dependent on foreign trade for the maintenance of their industrial societies. Some, such as Great Britain or Japan, imported much of their raw material, fuel and food and depended greatly on the exchange of their products for the things which they could not supply to themselves. Others, with large and varied resources, such as the United States and the USSR, were much less dependent on either resources or markets outside their borders. The great bulk of international trade was part of the pattern of mass consumption, for it was carried on between the most developed industrial countries and was based on the high income of these countries which furnished a market for the world's

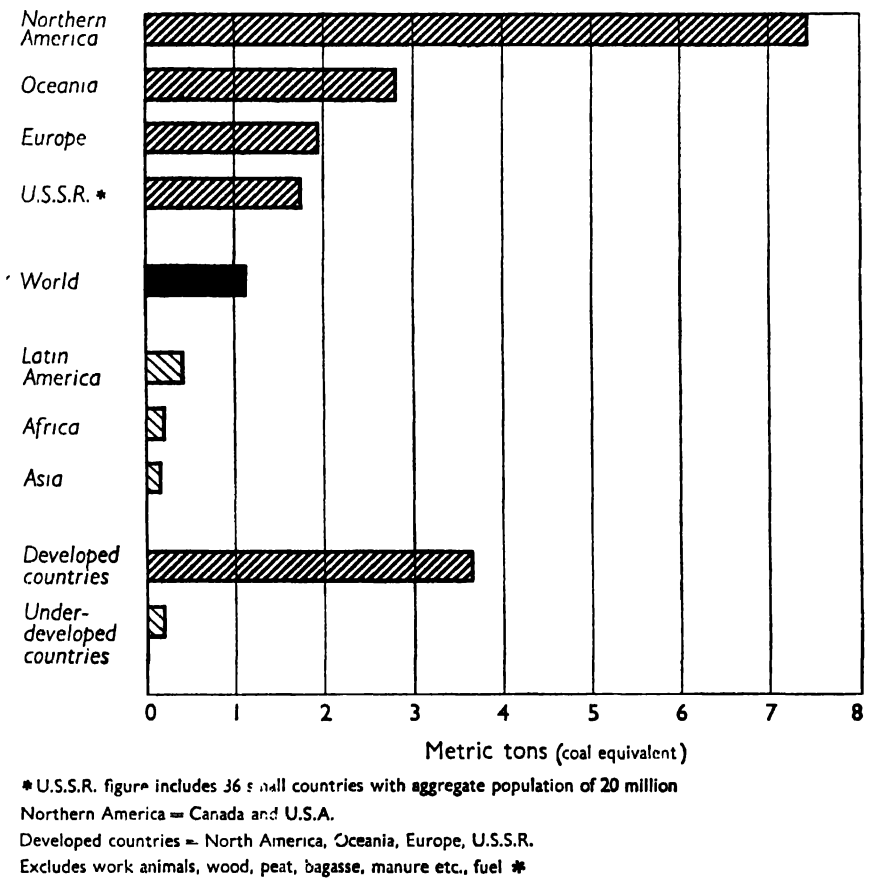


CHART IV. *Per Capita* Consumption of Energy, 1950, by regions.

Source: UN, *World Energy Supplies*, Statistical Papers, Series J, No. 1.

varied industrial products that the people of the non-industrial countries could not afford to buy.

Modern industry provided the incomes to sustain a mass market, for the rising productivity of its workers enabled it to pay higher and higher wages.

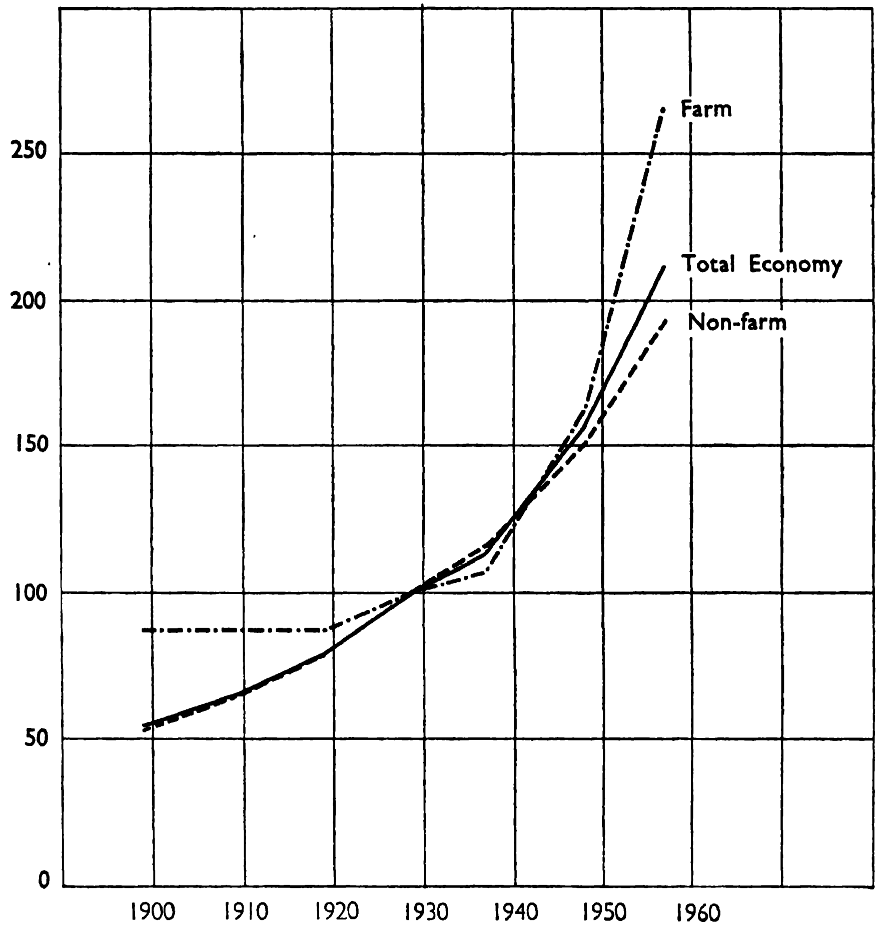


CHART V. Increase in Output per Man-hour, USA, 1899–1957 (index: 1929=100).
Source: U S Department of Commerce: *Historical Statistics of the U.S.A.*, p. 599.

In the most highly mechanized of the industrial countries, the United States, the average output per hour of labour in manufacturing more than doubled in these fifty years. The real income of workers rose correspondingly, so that the worker in 1948 was able to buy with twenty-eight hours of work what a typical worker of 1914 had had to work sixty-five hours to purchase. The mechanization of agriculture increased the productivity of the agricultural worker to a similar degree, raising the farmer's income and lowering food costs

to the urban worker. The modern worker also enjoyed new leisure, for the average work week in industry was shortened by a third between 1900 and 1950.

The result of industrialization was thus to spread higher levels of income and leisure through the society. An estimated 60 per cent of US families in 1950 enjoyed real incomes, adjusted for changes in the prices of the things that they bought, as high as those which only 30 per cent had enjoyed in 1935. At the other end of the scale less than 8 per cent of the families in 1950 were receiving incomes as low as those received by 20 per cent in 1935. Comparable data are not available for earlier years, but according to other estimates the incomes of 30 per cent of income-receivers in 1951 were the equivalent of those received by the upper 7 per cent in 1918.

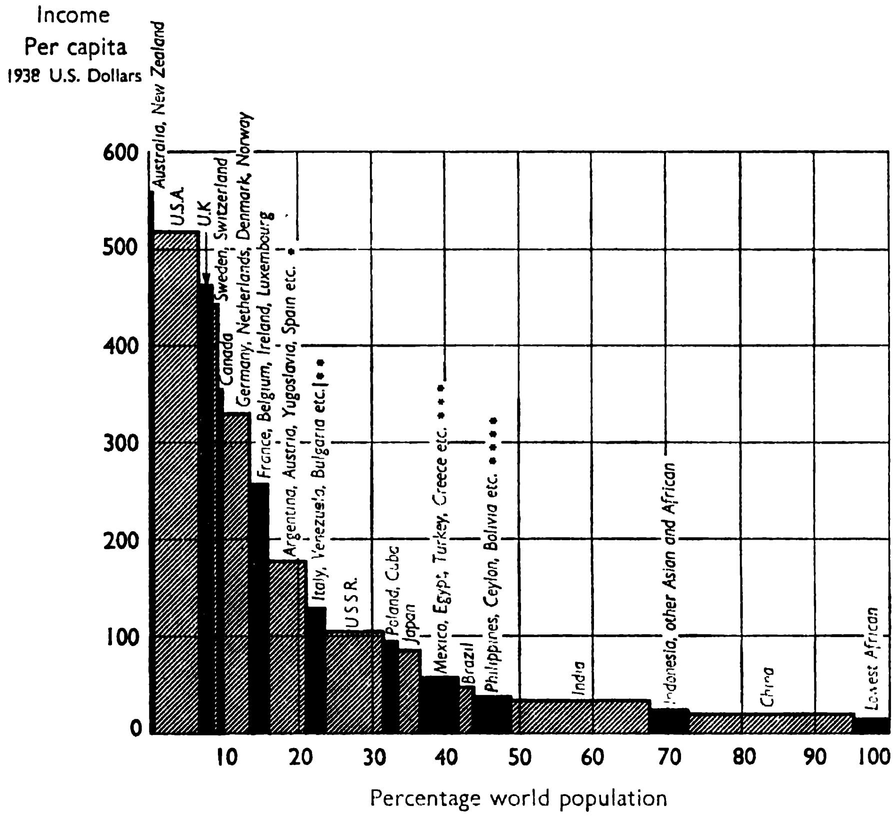
Although twentieth-century industrialism offered the basis for high levels of living for whole societies, this was an actuality only in those areas most thoroughly and modernly industrialized. At mid-century it was still only a potentiality in the areas whose industrial development was either less complete or less based upon the use of modern techniques, and an aspiration where industrialization had barely scratched the surface and was being eagerly sought as a road to national welfare.

Industrial production remained concentrated during the first half of the twentieth century in the countries where it had its origin and early development. At the middle of the century approximately 80 per cent of industrial production was still centred in the countries which had accounted for 98 per cent in the late nineteenth century—Great Britain, western and central Europe, Russia and the United States. In spite of the tendency of industrialization to spread, the only new areas where industrial development was sufficient to make a substantial contribution to the world's industrial production were Japan, Czechoslovakia, Canada, Australia, Poland, India and Argentina. In the last three of these countries and in most of the rest of the world, agriculture continued to employ well over half of the labour force—60 per cent or more in most countries of Latin America and east Europe, at least 75 per cent in most of the countries of Asia and north Africa, and, together with hunting and gathering, over 90 per cent in the rest of the African continent, exclusive of the European population of South Africa.

The general result of industrial development during these years was to widen the gap in real income between the industrial and the non-industrialized countries, and particularly between the latter and the countries of most advanced industrial technology and organization which had not been set back by wartime destruction: the United States, Canada, Australia, Sweden and Switzerland. In the non-industrial countries production rose little during the century while population in most areas increased, holding *per capita* incomes as low as or lower than in the past. In the United States, Britain and the Commonwealth countries, meantime, *per capita* income more than doubled, and it nearly trebled in Sweden. At mid-century *per capita* income in most of

the Latin American, Asian and African countries was less than 10 per cent that of the United States and less than 20 per cent that of Great Britain. In many parts of these areas the disparity was far greater.

Acceleration in the rate of development in the industrial areas threatened to widen the gap still further and intensify the impatience and frustration of



* Includes Hungary, Czechoslavakia, Finland, South Africa

** Includes some other South American

*** Includes some other North and Central African, and South American

**** Includes some other Central and South American, Asian and North African.

CHART VI. Distribution of World Income, 1938. *Per capita* (height of bars) and total (area of bars).

Source: Woytinsky, *World Population and Production*, pp. 389–96.

the 'have-nots'. Technological advance in the decade after the second world war stepped up the rate of production spectacularly in many lines. Measures in the capitalist countries to check the recurrence of depression offered the prospect that rates of growth during this decade would be maintained or exceeded. In the communist countries ever-higher production goals and the

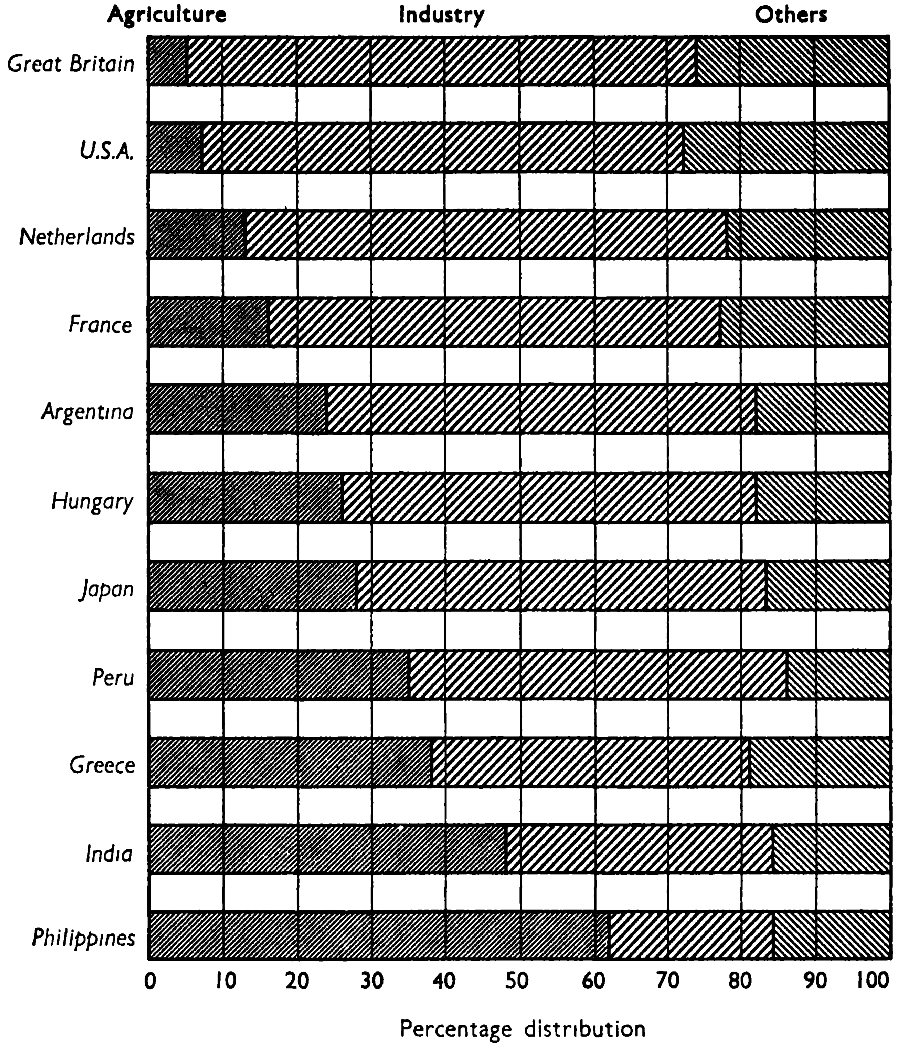


CHART VII. Income from Agriculture, Industry and other Sources, Selected Countries, *ca.* 1950 (percentage distribution).

Source: Woytinsky, *World Population and Production*, pp. 430, 433.

determination of the USSR to outstrip its capitalist rivals promised a maximum acceleration of industrial output and potential. As the industrial countries became more wealthy their resources for capital investment in further expansion became greater.

Most fundamentally of all, science itself constantly widened the gap. Industrial development became increasingly dependent on highly developed scientific and technical skills which the non-industrial countries could only

hope to build up slowly. The new science required such a high degree of knowledge and scientific sophistication that few outside the advanced scientific milieux were able even to understand the research of others, let alone carry it forward. Although the non-industrial countries had available to them the techniques which the industrial countries had evolved by slow degrees, and though they were prepared to make heroic efforts to catch up with their richer neighbours, the momentum of modern industrialism and the revolutionary pace of science kept carrying the developed countries further ahead.

The path of industrial development was not a smooth one during these years. On the one hand it was abnormally stimulated by war; on the other, industrial growth was periodically set back by depressions, war destruction and revolution. Industrial output fell off in Europe and America because of economic depression in 1907 and 1921, and the collapse of the 1930s was so severe that it shook the capitalist industrial countries to their foundations, shut down factories, sent unemployed workers into the streets, slowed down technological progress, caused the destruction of agricultural products for lack of markets and undermined the faith of many people in the ability of industry to fulfil its promise. At the lowest point of the 1930 depression production in the countries whose economies were most depressed—the United States and Germany—dropped by nearly a half from 1929 levels and it fell a third or more in several other industrial countries; in some countries as much as a quarter of the entire labour force was unemployed. The magnitude of the wasted manpower of these depression years in the United States alone was estimated as sufficient to replace the nation's entire physical capital, to rebuild its railways three times over or to supply a new, modern house for every family in the country.

Although the socialist economy of the USSR was free from economic crises and depressions, it suffered severely, as did the European economies, from war devastation. The first world war set back the industries of western, central and eastern Europe, and that of the USSR suffered additionally from the civil war and intervention of 1918–20. The destruction and disruption from the second world war was even greater. The war laid waste one-third of the urban housing of the USSR and uprooted one-third of its people; it reduced the *per capita* real income of the German people to hardly more than a third of the pre-war level or half of that which they had enjoyed at the opening of the century. Wars and military preparations diverted much industrial production from uses that would enhance economic well-being. The actual increase in industrial output in the industrially developed countries was thus kept well below the potentials which science, industrial technology and industrial organization made possible.

By mid-century industrial activity, which had been under few restraints and virtually no guidance at the beginning of the century, was everywhere subject to a considerable degree of control. The leaders of the Bolshevik revolution of 1917 were convinced that the capitalist organization under which industry had

initially developed could only make the rich richer and the poor poorer and would inevitably lead to recurrent economic collapse, and that a socialist economy was necessary in order to secure the benefits of industrialism without its disadvantages. In the USSR and most other communist countries industry was under central government direction.

In non-communist countries governments found themselves increasingly called upon to intervene to regulate one aspect of economic life after another. They adopted a variety of measures to protect workers, consumers, small business and investors, and to guide development by controls over the volume of money, the flow of capital and international exchange; they used their tax and spending policies to try to maintain economic stability. Countries that were newly aspiring to achieve the benefits of industrialization used planning, regulation and government spending to stimulate industrial activity.

The uses to which the potentialities of industrialism were put could differ markedly under different economic and social systems. Where production was guided by the demands of consumers and the efforts of producers to make a profit in meeting those demands, industrial capacity was devoted to a wide range of consumer goods, including those required by government for civil and military purposes, and to rival efforts by producers to stimulate consumer wants in directions which they found profitable. In such circumstances, the level of incomes and their distribution determined the extent to which production met the wants of the many or of the relatively wealthy few and was directed toward necessities or less essential products. Where there was central control and administration of production, as in the socialist economies, a comparable industrial potential could be directed, in line with the purposes and judgment of those in control, to the rapid expansion of the industrial and military base and to such consumer goods as were deemed necessary and appropriate.

Production could be directed toward the creation of an autarchic economy, as in Nazi Germany, or devoted to militaristic purposes as in Japan from 1926 to the outbreak of the second world war. In time of war all belligerent countries took steps to focus their industrial potential on war requirements. Newly developing countries were under great pressure to plan their economies in order to devote their limited capital resources and technical skills to the most urgent purposes.

Industrialism thus offered the basis for the development of various types of societies well supplied with material goods. Its essential processes made certain common demands on all, and thus in a measure shaped a common new culture, but it did not wholly determine the form of the increasingly affluent societies which it made possible.

II. THE SPREAD OF INDUSTRIALISM

The spread of industry from its early home in Great Britain, western Europe and the United States to the regions of eastern and southern Europe, the over-

seas areas of the British commonwealth, and into the non-industrial regions of Asia, Africa and Latin America followed distinct patterns. In parts of Europe outside the original nucleus and in areas of European settlement abroad the expansion of industry reflected the gradual spread of enterprise either through investment from other countries or through the establishment of mines or factories with local capital. In much of Asia, Africa and Latin America the introduction of industry represented either the effort of foreign capital to exploit the natural resources of a colonial or economically undeveloped area, or the struggle of a newly aroused state to enhance its national status and raise the living standards of its people.

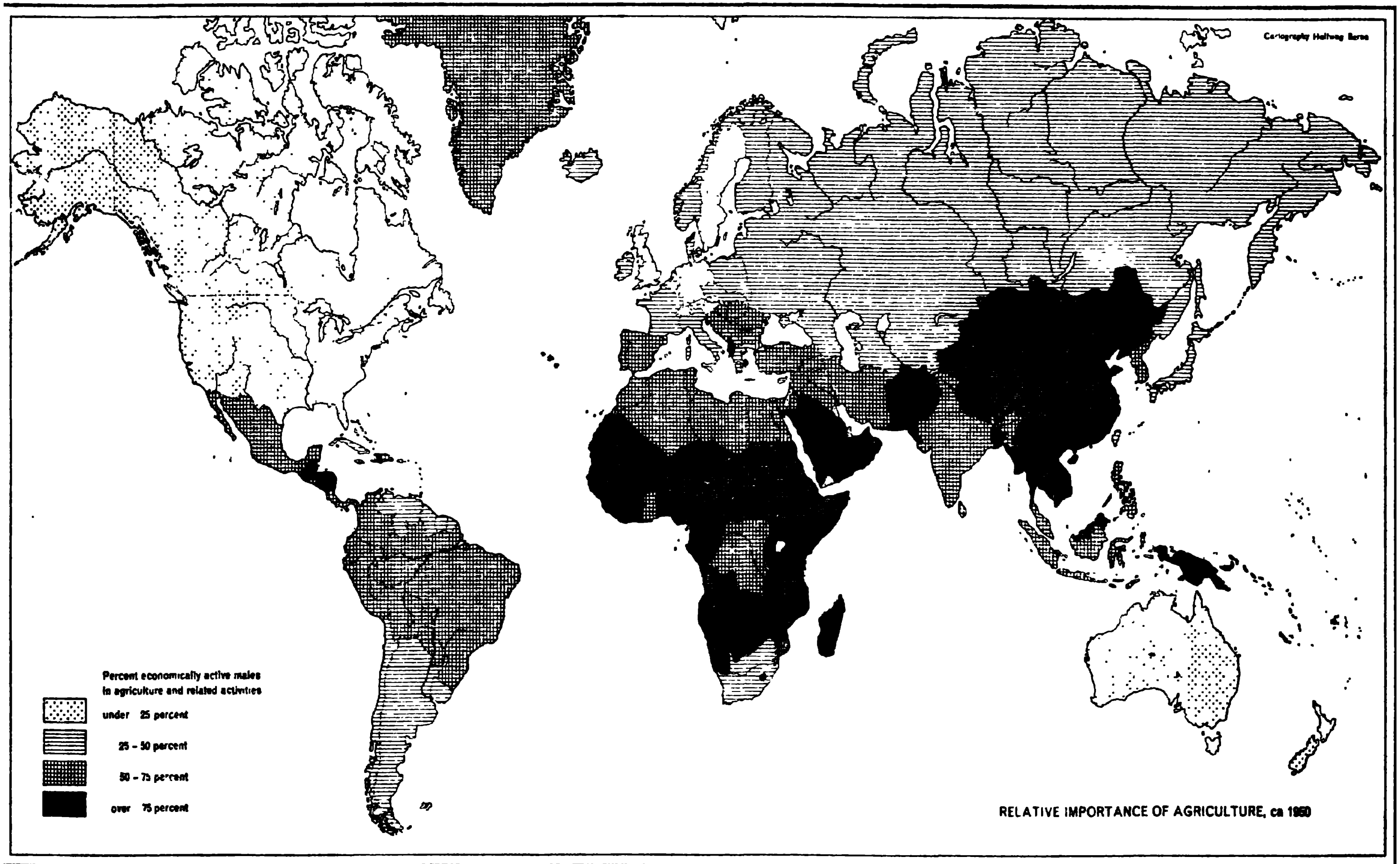
1. *Extension of enterprise*

In eastern Europe substantial industrial developments based on the coalfields and textile industries of Poland and the iron and ceramics industries of Bohemia brought important parts of the region into the industrial fold before the first world war. Thereafter industrialization followed a chequered course. Growth was halted temporarily by the destruction of the first world war and the economic reorientation involved in the establishment of new national states. It had barely been resumed when the world economic depression brought another sharp set-back, and then the disorganization and destruction of the second world war followed. In the years after the war there was another reorientation as the further industrial development of eastern Europe took place under communist leadership and in close relation with the economy of the USSR.

Industrial development in the British commonwealth countries, especially Australia, and also in India, received a great stimulus when the first world war cut off normal European supplies. Canadian industry developed as a natural extension from the United States and experienced the same types of industrial growth. In these areas of transplanted European culture industrialism took root and flourished in the same manner and even more freely than in the older areas. These countries provided their own markets for diversified, balanced interdependent production, and participated as industrial producers and consumers in the general flow of world trade.

2. *Foreign investment*

No such general industrialization took place in the areas which were penetrated by foreign capital in search of profitable investments in raw materials to supply the insatiable demands of European and American industry: copper and gold in Africa, tin in Bolivia and Malaya, rubber in Malaya and Indonesia, iron in Labrador, petroleum in Venezuela, Borneo, Sumatra, and the Persian Gulf, coconut oil on the islands of the Pacific, uranium in the Belgian Congo and many other products elsewhere. Where industry reached new areas by means of foreign enterprises which developed mines or oilfields, rubber plantations or jute mills, it had little effect in industrializing these countries,



RELATIVE IMPORTANCE OF AGRICULTURE, ca 1950

although it did provide sources of income, introduce some new knowledge and skills and develop some supporting institutions. Operating under the protection of colonial rule, or with the aid of unequal treaties such as those with China and Turkey giving extra-territorial jurisdiction or spheres of influence to Europeans, or under agreements negotiated with local governments as in Latin America or the oil-rich Arab states, these enterprises constituted enclaves within the non-industrial areas where they functioned. Equipment, technicians and managers were brought in from outside; products flowed out. Profits from the enterprise, gained from sale of the product abroad, went mainly to the foreign investors or were spent abroad to pay for equipment and to buy the things which entered into the standard of living of the foreign personnel and the small group of local people who were associated with management.

The wages of labour were not sufficient to provide a substantial market and thus to stimulate other local production. Sometimes imported products found their way into the company store of a foreign concern and thence to the local worker's home. But the kind of spiral which was set in motion in industrial countries, when local production for a local market generated income which provided a further market and stimulated production of other products, was almost wholly absent under the conditions of foreign enterprise in underdeveloped areas.

Local interests sometimes sought to encourage foreign investment of this sort, but often they resented bitterly the return of profits to the country of the capital investors; the privileges exercised by representatives of foreign firms were offensive to the dignity and self-respect of the people of the locality. Some local governments secured royalty agreements and imposed taxes which retained large profits from these foreign enterprises, as in the case of oil profits in Venezuela and the Persian Gulf. But such revenues often went to enrich the ruler or a limited group in power, and even when they were used for public purposes they were more likely to be spent on roads, hospitals or schools than invested in local productive enterprise, and they did not substantially alter the non-industrial character of these countries.

3. *Conscious efforts to industrialize*

Quite different in process and results were the conscious efforts of non-industrial countries to remake their economies and to achieve the advantages of industrialism for their own people. Japan was the first to make this effort, starting in the late years of the nineteenth century and gathering momentum from the early twentieth. Russia after the October revolution undertook to build a great industrial empire on the narrow but scientifically and technically grounded base of pre-Soviet Russian industry. Mexico and Argentina led the Latin American countries in the extent to which they expanded the industrial sector of their basically agrarian societies, and remained in the forefront as other Latin American countries undertook national programmes of economic

development in the years after the second world war. At mid-century the Asian countries, released from colonial control or Western economic domination, were straining to achieve the most rapid industrial development within their power, either seeking this objective within the framework of democratic political institutions and a partially capitalist economy, as did India, or adopting the communist course, as did China.

(*a*) *Japan.* Each of the conscious efforts at self-industrialization reflected the direct aspirations of a nation and its concept of national progress. For Japan the determination to remain free from the encroaching colonialism of the western powers led her in the late nineteenth century to seek industrialization as a basis for military strength. The pattern of industrialization reflected the unique situation of a compact, nationally integrated society, capable of responding to a national leadership which undertook to change its orientation.

Japanese industrialism was built on the foundations of pre-industrial society and did not destroy them. The feudal structure of that society with many small centres of prestige and power provided a source of widespread entrepreneurial initiative; a substantial class of merchants and artisans producing for the imperial court and the feudal households offered a supply of skilled workers; an agricultural economy unable to support an expanded population furnished a reservoir of unskilled labour; a number of urban centres around the court and feudal administrative units could readily become a series of industrial centres when linked by sea or rail and provided with electric power.

Since the objective of Japan's industrialization was to make possible a strong military position, the government gave its major support to the development of heavy industry through state operated, financed or sponsored enterprises. But the country lacked materials for such industries, and it was necessary to seek these from outside through trade, territorial expansion or investment abroad. Accordingly Japan developed export products which did not depend on the scarce materials and capital needed for the major sector and could be produced with a minimum of machinery by the labour of girls drawn from rural areas and by the use of the capital resources and initiative of the poorer gentry and merchant classes. In the early years of the twentieth century Japan moved into the world markets as a large supplier of cheap textiles, toys and wooden and glass objects. To reduce dependence on the uncertainties of this market she then sought direct control of resources outside her immediate borders, developing Korea and invading Manchuria in order to tap the coal and iron of that rich region.

As basic heavy industry developed and light export industries grew to help sustain it, a third sector of Japanese industry emerged to meet the demands of the home market. Wages earned in industry, though low, constituted a source of buying power which supported a variety of additional industries; workers in these industries, in turn, became part of the market for a growing, diversified range of production. In spite of its military orientation Japanese industrial development was thus a balanced and largely self-sustaining growth.

By the end of the first quarter of the twentieth century Japan had become one of the major industrial nations although, with her dense population, her *per capita* income never equalled that of any European country except the poorest among them—Rumania, Bulgaria, Greece or Portugal—or amounted at any time to as much as a fifth of that of the United States. But on the eve of the second world war her aggregate production amounted to two-fifths that of Great Britain and four-fifths that of France, and was exceeded by no other countries except the United States, Germany and Russia. Less than half of her labour force, which had become educated and technically trained, remained in agriculture.

(*b*) *The USSR.* The industrialization of the USSR, within the framework of a communist society, followed a vastly different course, under the differing conditions provided by the large area, rich natural resources and heterogeneous population of the Soviet Union and by its revolutionary social system. In contrast to Japan which retained much of its pre-industrial structure, the communist revolution eliminated the feudal centres of wealth and potential leadership. In addition, the USSR undertook to industrialize agriculture at the same time that it developed industry, while Japan left its agricultural system essentially unchanged. As soon as the Russian industrial programme gained momentum after 1928, moreover, it operated in the presence of a labour shortage rather than a reservoir of surplus rural workers as was the case in Japan. Socialization of the basic means of production and centralized utilization of economic revenue through the state budget made it possible, for the first time in history, to effect deliberate industrialization according to a uniform economic plan.

Soviet industrialization was very largely self-contained, drawing from accumulations of the socialist economy. Except for some initial acquisition of machinery and the hiring of foreign technicians in the early stages, the Soviet Union had little dependence on imports or need to seek an export market in order to finance them. It was, therefore, able to concentrate almost wholly on the development of heavy industry in order to lay a basis for industrial expansion and the mechanization of agriculture and to provide the military strength made necessary by a far from friendly environment. By means of widespread technical education at every level, in factory, school, labour institute and university, it developed the technical personnel essential for industrial growth.

In concentrating initially on heavy industry the USSR departed from the pattern which had characterized industrial development in most other countries, where textile and other light industries led the way. Its system of planning enabled it to start with production of capital goods before there was a developed market for the industries they would supply. It also made it possible to prevent consumer industries from developing in response to domestic demand as they did in the older industrial countries and in Japan, and to limit this type of production to what were considered the minimum needs of the

people during the period of concentration on heavy industry. The expansion of consumer industries, planned to follow when heavy industries should be sufficiently well established, was delayed by the military demands and the physical destruction of the second world war and by the military build-up which continued in the face of world tensions in the post-war decade. Although levels of consumption remained low for some time and *per capita* income in the USSR in the early 1950s was still less than a third of that in Canada or Switzerland, the light goods and food industries were expanding rapidly and consumption was rising. The high rate of industrial growth in the 1950s revealed a dynamic economy prepared to bid for world industrial leadership.[1]

(*c*) *Economically underdeveloped countries.* The underdeveloped countries of Asia, Africa and Latin America which consciously strove for economic development after the second world war had their eyes primarily on the gulf in living standards between their people and those of the industrially developed countries, and on the problem of how to make the best use of their own resources for their own people. The vision of plenty, or at least of the reduction and ultimate elimination of want, led them to initiate programmes to stimulate economic activity, establish machinery for planning, undertake technical education, explore sources of capital and seek to develop managerial skills.

In launching these efforts they recognized that they were embarked on fundamental changes in their societies, for the experience of the industrially developed countries had shown that industrialization did not take place partially while the rest of life remained unchanged. It could not fail to break down the status structure of Asian societies or to bring detribalization to desert peoples and African tribes.

Industrialization involved a reorientation of the essentially colonial economies of these countries as well as their expansion. This process was far from simple, for existing structures of trade and finance tended to perpetuate dependence on countries of advanced economic organization.

Still more, industrialization involved a change in outlook, for it produced and required general technical-mindedness and a network of institutions to keep an industrially organized and mechanically equipped society in operation. The widespread use of automobiles and radios was almost as dependent on petrol service stations every few miles and radio mechanics in every neighbourhood as on automobile and radio factories, while mechanized agriculture required either that every farmer become a mechanic or that tractor stations be set up throughout the rural areas. Many sad examples of agricultural or other machinery introduced into non-industrial areas and wastefully abandoned for lack of mechanics or spare parts served as warning that piecemeal industrialization would not be effective.

The countries which aspired to rapid industrialization in the middle of the twentieth century had many advantages as well as many problems. They had

access to the latest techniques, so that some of the most modern factories in the world were to be found in countries beginning their industrial development, yet they lacked the technical personnel required to make use of the latest devices. They were unhampered by the presence of existing investments in older machines or methods and could adopt new techniques without opposition from vested interests. In this they had some of the same advantages that latecomers to industrialization in the nineteenth century, such as Germany and the United States, had enjoyed over the pioneer industrial country, Britain. New energy sources and new materials that were being developed, including atomic and solar energy, light metals and plastics, promised to free the newly industrializing countries in time from dependence on traditional energy sources—coal, oil, water-power—and on some of the conventional materials such as iron which many of them lacked. At the same time these developments created a new dependence on scientific and technical knowledge.

The international atmosphere, moreover, was favourable to the success of their efforts, for the technically advanced countries were prepared in some degree to share their know-how and to help them to move ahead. The flow of technical knowledge was far from free, for private companies protected their trade secrets and patents, and governments tried to guard knowledge deemed vital to national defence. But there was a growing recognition that economic as well as political colonialism of the old type was doomed, and that countries which had benefited from industrialization would serve their own self-interest if they helped to reduce the gap between the levels of living of the 'have' and the 'have-not' peoples. International agencies provided channels for technical assistance and some financial aid toward this end.

Yet although the desire for industrialization was general, the absence of trained technicians, experienced managers, and institutions, habits and attitudes associated with modern enterprise presented serious obstacles. The great problem was how to mobilize the means, the understanding and the will to effect the transformation necessary to bring substantial benefits to non-industrial areas.

The situation was far more difficult than that which had accompanied the industrial development of Europe and North America. The first 150 years of industrialization had coincided with the opening up of new, sparsely occupied lands in the Americas, Siberia, Australia. In Europe and North America industrial development kept ahead of population growth, while open lands provided an additional outlet for European peasant populations. The combination of new lands, colonial wealth and a moderate rate of population growth had enabled Britain and western Europe to achieve the momentum of industrialization. Even so, the transformation of the peasant societies of eastern Europe had still not been achieved.

The non-industrial countries of the mid-century did not have these advantages. There were, indeed, vast empty lands, arid or formerly inacces-

sible, which new technology was making available for settlement. But to conquer these new frontiers required great resources and scientific skills. The new countries could not draw on the wealth of distant colonies, nor did they experience moderate rates of population increase. On the contrary, modern medicine was reaching every part of the globe, to wipe out age-old diseases which had kept population growth in check. In nearly every non-industrial area death rates were dropping sharply and population was growing at an accelerating rate. The measures taken to promote economic expansion in the decade after the second world war, though extensive, were small in relation to the task, and in some instances they could hardly do more than prevent economic conditions from becoming worse. During the 1950s none of these countries reached the point where its industrial development was self-generating and self-sustaining.

The central questions which industrialization posed for these countries were perhaps as much cultural as technical: Did they have the drives which industrial development required and could the integrity of their societies be maintained and the benefits of industrialism also be enjoyed? Since the cultures of all the countries at an advanced stage of industrialization gave value and dignity to work, could industrialization be achieved by those where work had been traditionally regarded as an indignity or a curse to be avoided or unloaded on to the backs of others if possible? Since the culture of the capitalist countries sanctioned the quest for private gain, was capitalistic development possible where personal gain was an unworthy objective for those groups in the population which had the wealth, education and prestige that would make them potential sources of industrial leadership? Could some commitment to the welfare of society provide the necessary moving spirit and some non-authoritarian form of planning provide the method in countries which did not wish to adopt authoritarian political forms or to support their industrial programmes and economic policies by the kinds of force which were employed by communist states to direct economic development?

The most basic problem for these countries lay in the need to develop a scientific orientation and to master not merely techniques which could be imported or readily learned but the immensely complex and austere disciplines of scientific knowledge and thought which alone could sustain modern industrial society.[2, 3, 4]

NOTES TO CHAPTER IV

1. Doctor of Historical Sciences G. N. Golikov asserts that the authors give a distorted picture of the policy of socialist industrialization as carried out in the USSR. The necessity for high tempos of industrial development in our socialist state was dictated by the country's technical and economic backwardness, the heritage of tsarist Russia, and the threat of intervention by aggressive imperialist states. In December 1925 the fourteenth congress of the VKP(b) (All-Union Communist Party (Bolsheviks)), guided by the

teaching of V. I. Lenin on the maximum development of heavy machine industry and the electrification of the country, put before the Soviet people the task of carrying out the socialist industrialization of the USSR, creating the material and technical foundation of socialism, and turning the country from one economically dependent on the capitalist states into a socialist power. The concrete tasks that had to be solved in the course of industrialization were as follows: the re-equipment of old plants and factories on the basis of new technology; the creation of branches of industry that had not existed in pre-revolutionary Russia; the construction of factories for building machines, machine tools, motor vehicles, chemicals and metallurgical works; the organization in Soviet Russia of the production of motors and equipment for electric power-stations; an increase in the output of metals and coal; the establishment of a new defence industry to strengthen the Soviet Union's defensive might; the construction of tractor plants and enterprises producing modern agricultural machinery, thereby creating the material and technical foundation for agriculture and making possible the transition from millions of small individual peasant farms to a system of large-scale collective farming. In contrast to the capitalist countries, which as a rule began their industrialization with the development of light industry, the Soviet Union launched on industrialization with the development of heavy industry.

The solution of all these very complex economic tasks necessitated the overcoming of difficulties, and above all a search for the tremendous capital investments which industrialization required. In the hands of the socialist state were the key positions in the economy: factories, plants, land, transport, banks, foreign trade and so on, and this opened up opportunities for the socialist accumulation of resources for industrialization. The party and government stimulated the political activity and zeal for labour of all the working people, mobilizing them in their struggle to bring down production costs, raise the productivity of labour, and lower costs of production.

As a result of the fulfilment of the First Five-Year Plan at the beginning of 1933 the Soviet Union was converted from an agrarian country into a socialist Power with an industrial base and a collective-farm economy. The share of industry in the economy rose to 70·7 per cent in 1932.

The foundation of a socialist economy had been built. Unemployment had been eliminated and the conditions created for an uninterrupted improvement in the material position of the working people in town and countryside, and for a rise in their cultural level.

2. The text has been criticized for accepting the anti-colonialism formula too uncritically. Professor Giorgio Janiot finds the text one-sided in its analysis of capitalist colonialism and calls attention to the investments made by the colonial powers which have left real wealth in the form of income and installations and 'serve to put the decolonized countries on the path of economic and industrial development'. Professor Lynn M. Case thinks that the authors should not have stopped with a statement of the difficulties encountered by some of the new states, but should have suggested that independence might have been premature.

Professor E. N. Anderson observes that it is true that some of the newly independent states are too small and lacking in resources to provide a viable base for economic development. The immediate tendency of the new African states to form one or another sort of union testifies to their recognition of this fact, as do similar steps toward the establishment of common market or other integrating relationships among groups of older economically under-developed countries such as the Central American republics. At the same time, independence has provided the indispensable basis for measures designed to reorient local economies with the prime object of raising the income and levels of living of the population rather than of providing raw materials for foreign industry or tropical products for foreign consumption.

3. Doctor of Historical Sciences L. I. Zubok underlines that the principal difficulties facing the under-developed countries are the consequence of several centuries of colonial rule and the exploitation of these countries by imperialism.

Several Western European sociologists are attempting to prove that the colonial regime was really a blessing for the enslaved countries and propound the thesis of the civilizing

mission of colonialism. For example, Cardinal Mercier defines colonialism as a collective act of mercy accomplished by more developed nations on behalf of unfortunate races and as being the inevitable consequence of cultural superiority (*'Cahiers Internationaux de Sociologie*, vol. XVII, July–December 1954, p. 8).

The facts would have it differently. In resources and ancient culture alone, the rich African continent lost nearly 150 million people as a result of the hunting of the Negro and other acts of the colonialists (cf. Jacques Arnault, *Procès du Colonialisme*, Paris, 1958, p. 87). In three hundred years, its population fell from one-fifth of the population of the world to one-fourteenth; 90 per cent of the inhabitants could neither read nor write; the numbers engaged in the industrial production of the capitalist world accounted for only slightly more than 1 per cent.

In the post-war years, the question of aid to under-developed countries has not disappeared from the agenda of international conferences. Thus the industrially developed countries possessing modern techniques and qualified personnel can make a significant contribution towards easing the tasks faced by the peoples of the under-developed countries. But the whole problem is that of the conditions under which this aid will be furnished.

The basic task confronting the under-developed countries is that of the swifter development of the forces of production, and to increase production sharply in order to meet the urgent needs of the population. The basic approach towards solving this problem is to increase productive labour and the mechanization of production. However, many Western economists starting from obvious premises, apparently consider that since the under-developed countries have a large surplus of free labour and are very short of capital, they should concentrate on creating undertakings with little mechanization and use manual labour to a much greater extent (cf. the article of the American theoretician H. W. Singer in *Social Research*, Spring 1953, pp. 25–6; B. Higgins in *Land Economics*, vol. XXXI, No. 3, August 1955 and others).

In speaking out against the industrialization of the under-developed countries, the Western powers are endeavouring to promote the backwardness of those countries so that they can exploit them. They consider the best form of assistance to be different government loans and grants and the export of private capital so that in the end it leads to the outflow of enormous sums from the country in the form of percentages, dividends and so on. The overwhelming part of Western aid takes the form of arms deliveries and the sale of agricultural surpluses. Industrial equipment is virtually never provided and insignificant amounts are allocated for technical experts. Quite often the aid is tied to some political condition or other.

As a result, imperialistic exploitation of the under-developed countries still goes on to-day. For instance, according to the British oil information office, out of the 496·2 million tons of oil produced in 1960 in industrially under-developed regions, nearly 433·2 million tons, or more than 87 per cent, was obtained by firms controlled by American, English or Dutch capital.

Thus, one of the primary tasks in the economic advancement of the under-developed countries still remains the removal of the consequences of colonialism and the struggle with neo-colonialism in all its forms.

See:

Kolonializm včera i segodnja [Colonialism yesterday and to-day] (Moscow, 1964).

E. D. Modrzhinskaya, 'Zaščitniki sovremennogo kolonializma' [The advocates of present-day colonialism] and V. Kolontai, 'Protivniki ėkonomičeskoj nezavisimosti slaborazvityh stran' [Opponents of economic independence for under-developed countries] in the collection *Istoričeskij materialism i social'naja filosofija sovremennoj burzuazii* [Historical materialism and the social philosophy of the present-day bourgeoisie] (Moscow, 1960).

Kolonializm i mežimperialističeskie protivorečija v Afrike [Colonialism and international imperialistic contradictions in Africa] (Moscow, 1962).

Y. Y. Etenger, *The expansion of the Federal German Republic in the Arab countries and Africa.*

4. *The Author-Editors make the following additional comment to the question of the economic development of former colonial countries:*

The problems faced by one-time colonial countries in their efforts to develop viable economies and to begin to close the gap between themselves and the economically developed countries are increasingly preoccupying the world community, and are revealing themselves as more complex than any of the simple formulae about "colonialism". The United Nations have declared the decade of the 1960's as the "Development Decade" in the effort to focus world intelligence, good will, and practical co-operation toward this end. The crux of the matter lies, in part, in the problem of generating or securing sufficient investments to mount a modern economic development process. This has been one of the major concerns of the successive Indian Five-Year Plans.

The inescapable need to draw on expertise and investment funds from abroad in order to develop local resources and begin to meet the aspirations of the people presents a double problem: (1) the organization of such assistance on the part of the countries in a position to render it, and (2) its use by the developing countries in a manner which avoids the reintroduction of forms of dependency which independence has sought to break. The establishment of the United Nations Special Fund for Development, the creation of a variety of aid and loan systems by the countries of Western Europe, the USA and the USSR, and measures to attract and promote private investment on the part of both capital-receiving and capital-supplying countries have been among the efforts to meet the situation. The developing countries have endeavoured to avoid a monopoly of influence by seeking funds and technical assistance from a number of countries and, wherever possible, by utilizing the aid of international agencies.

It has become increasingly apparent that in the interdependent modern world where industry, technology, politics, and many forms of communication afford a multiplicity of means for influencing peoples, the concept of 'colonialism', 'anti-colonialism' or 'neo-colonialism' is too simple to describe these interrelationships or the problems which once-colonial countries share with other economically under-developed states which are seeking modernization.

See:

Rupert Emerson, From Empire to Nation: the Rise to Self-Assertion of Asian and African Peoples (*Cambridge, Mass., 1960*).

John Petrov Plamenatz, On Alien Rule and Self-Government (*London, 1960*).

Robert Strausz-Hupé (ed.), The Idea of Colonialism (*New York, 1958*).

CHAPTER V

THE CHANGING SOCIETY

THE developments of these years brought social and cultural changes no less drastic than the shift in power and the changes in the political and economic systems of the world. These social changes reflected three major factors: the development and impact of science and technology, the interaction between cultures characterized by advanced technology and the cultures of other parts of the world: and the processes of revolution aimed at the conscious remaking of societies. In the industrial countries industrialism remade the patterns of life. In the non-industrial areas changes in outlook and social organization were even more radical than those in the industrial countries, which by the opening of the twentieth century had already gone far toward adopting a scientific orientation.

The interaction between technically advanced cultures and other societies modified the traditional social patterns and stimulated a renaissance of the cultural values and vitality of many areas. The process became a universal one throughout the world, though it operated in differing manners and degrees under conditions of colonial impact and liberation from colonial rule, or where contact was through trade and investment, or where isolated peoples were becoming integrated into modern states of which they formed a part, as were some Indian populations in Central and South America and some of the Asian peoples within the Soviet Union.

Revolutionary movements which undertook to build new societies brought other forms of fundamental social changes. The October revolution in Russia followed by the socialist reconstruction of Russian society stands out as the major conscious revolutionary transformation of the first half of the twentieth century, but this was not the only revolutionary phenomenon. The Mexican revolution which began in 1910 went far toward destroying the social pattern based on large-scale landholding, as did the revolutionary peasant movements in eastern Europe after the first world war and revolutions in Bolivia and Cuba in the 1950s. Under the leadership of Ataturk, the Turkish revolution of the 1920s remade the legal structure, the position of women and the place of religion in the state. The people's democracies of eastern Europe, and especially the People's Republic of China, profiting by the experience of the USSR, undertook to build socialist societies leading toward communism, in line with the situations in their respective countries. Every country which successfully freed itself from colonial rule projected more or less directly a new social pattern which it sought consciously to realize.

These trends radically altered the relation between classes and groups of people, both within and among societies. They had the effect of uprooting many millions of people and brought a staggering rate of population growth far above anything which the world had ever known. The disruptions of two world wars loosened many social bonds. Cultural impact combined with the spirit of nationalism to bring new outlooks. The growth of large organizations, both political and economic, created a new framework for the individual and placed new demands upon him.

The children born into the second half of the twentieth century, in all parts of the world, entered a milieu radically unlike that which their immediate forebears had known before the opening of the century.

I. IMPACT OF INDUSTRIALISM ON THE SOCIETIES OF INDUSTRIAL COUNTRIES

In the industrial countries the new industrialism penetrated rapidly through all segments of life. At the opening of the century, even in the most industrially advanced areas, many aspects of life were largely untouched. Only the beginnings of industrial transformation were then present. Railways carried great loads of men and goods four or five times as fast as a lightly loaded horse could travel, steamships doubled the speed and multiplied the tonnage of fast sailing vessels, and the telegraph, followed by the telephone, brought the first swift communication; but highway travel was still at a horse's pace, man was earthbound, and wireless communication was not in use; the machine gun and heavily armoured battleship presaged mechanized warfare, but barely hinted at its future extent; agriculture had begun to use mechanical equipment and the first of the mechanical household appliances, the sewing machine, had entered the home; the organ grinder was able to entertain city children with mechanically produced music.

But at the opening of the century transport and communication, warfare, agriculture, the home and the arts had only begun to be modified. During the first fifty years of the century—in fact during the first quarter—these and many other aspects of life were partly or fully industrialized by the application of machine technology or by their incorporation into the industrial structure.

The most dramatic change came in transport and communication. Man's relation to distance had already been so revolutionized by railways, steam navigation and telegraph that a second revolution in transport and communication hardly seemed possible. Yet the changes brought by motor transport, and especially aviation and radio communication, were no less drastic than those from steam and telegraphy. In the course of the twentieth century motor vehicles brought to every doorstep served by a street or road transport as rapid as that provided by all but the fastest trains. Air travel multiplied maximum ground speeds as much as the railway and motor car multiplied the speed of the horse, and the aeroplane was bound by no rail or

road or blocked by mountain, desert, sea or arctic ice. When aircraft began to exceed the speed of sound after the second world war, there appeared to be virtually no limit to the rate of travel that might be obtained and each new record, such as the non-stop circumnavigation of the globe at the equator in forty-five hours in 1957, was merely a temporary record, for single jet-planes had already reached speeds which would cut that record in half. Earth satellites circled the globe through outer space in one and a half hours.

In short, whenever it was essential to bring people to a given spot—for rescue on land or sea, for quick medical attention, for diplomatic conference, for wartime destruction—the barrier of distance was virtually eliminated. Instantaneous communication by telephone and radio, telephoto and television completed the conquest of distance and the reduction of the size of the world. The chance for men to live in isolation or seclusion grew rapidly less; few places on the globe could not be reached by plane and none was beyond the potential reach of a radio voice.

Mechanization of warfare and the application of industrial methods to the production of implements of war not only brought the unprecedented horrors of mass warfare in the prolonged stalemate of the first world war and the aerial bombardments of the second and led to the nuclear arms race of the post-war decade; it changed the place of war in society, for it converted the whole community into a military target and all but eliminated the old distinction between soldier and noncombatant.

The mechanization of agriculture, which had begun with the commercial production of the iron plough in the second quarter of the nineteenth century, had reached considerable proportions with the introduction of the reaper and harvester on North American wheat fields later in the century. But it entered a new phase with the development of the tractor on the eve of the first world war and the application of electric power on the farm. The use of tractors, which largely replaced horse-power on the commercial farms of North America and much of western Europe and Russia, substituted the petroleum industry and motor manufacture for the land and the farm labour that had supported horses and raised their feed; together with a wide variety of mechanical attachments, it enabled a single farmer on a fully mechanized North American farm to perform some tasks which required the labour of four men on a partially mechanized European farm and as many as forty men in the traditionally operated agriculture of Asia. The use of farm machinery, moreover, forced the farmer to become a mechanic. More fundamentally, new agricultural technology, which included the use of a host of commercially produced fertilizers, chemical insecticides and improved seeds, and the introduction of a variety of experimentally tested methods of cultivation, transformed the farmer from a conservative follower of custom and tradition into a scientifically minded experimenter and innovator.

Industrialism reached into the home, taking to the factory such traditional home tasks as the making of clothing, laundering and the preparation and

preservation of many kinds of food, and bringing into the home mechanical appliances for cooking by electricity or gas, sewing, cleaning, laundering and refrigeration. It played a part in changing the position of women as it drew them out of the home to follow their traditional tasks into the factory, and as it freed them from endless home drudgery and enabled them to engage in other occupations, and to take a fuller part in other aspects of family and community life.

Industrialization had its impact, too, on the use of leisure. Mass entertainment for those to whom industry gave new leisure was itself mass-produced by the new motion picture, radio and television industries. Aiming at mass audiences, these new media enlarged the horizons of the many, though they often offended the taste of the few, and they became an integral part of the life of modern societies, involving a vast network of productive units and employing a large body of people with very specialized skills.

The mass production of newsprint and technical developments in printing, telecommunication and radio, together with the spread of mass literacy which industrialism demanded, revolutionized the press. From a relatively simple instrument which provided political and business information and editorial opinion for a limited group of merchants, politicians and other men of affairs, the daily press became an increasingly complex mass-vehicle for the transmission of a wide range of news and information to satisfy the curiosity and provide entertainment for the general public. Mass audiences and new techniques for printing, photography and sound recording had the dual effect on the arts of stimulating the tendency to cater to mass taste and of making works of the finest quality available to the many.

In these and many other ways the life of the industrially developed countries became permeated by the features of industrialism—mechanization, mass production and the scientific attitude. Much remained unmechanized and unorganized—in the home, in the practice of the liberal professions, in various services and in the arts—but daily life was touched at almost every point by industry's structure or its products, and the scientific attitudes of rationality and acceptance of change penetrated even into those aspects which were not modified by mechanization or productive organization.

Industrialization radically changed the occupational structure of the industrial countries. Skilled craftsmen who had constituted the aristocracy of labour lost their position as their trades became obsolete; unskilled workers found themselves replaced by machines. In their places a new group of trained engineers and managers, technicians, salesmen, statisticians, office workers, advertisers, operatives and mechanics arose to plan, design, manage and carry on the processes of modern industry and distribute its products. New occupations developed in wholly new industries such as radio or aviation, motion pictures or plastics. With mounting requirements for scientific research and diversified education, with more wealth and greater leisure, professions and service occupations expanded and the numbers

of scientists, teachers, doctors, nurses, entertainers, restaurant keepers and providers of holiday and travel facilities multiplied.

The old class structure fell before the changes in occupations and sources of income. Where a landed aristocracy had dominated, men of industry shouldered them aside, leaving hollow titles with waning prestige. The old, small middle class of professionals, tradesmen and skilled craftsmen was overshadowed by a vast new army of industrial technicians, administrators and every sort of white-collar worker.

Modern industrialism, in fact, tended to push the bulk of the population toward the middle class. Although it did not eliminate the distance between richest and poorest and wide disparities remained, it steadily reduced the proportion which fell in these extremes and tremendously expanded the great middle group. Rising incomes reduced distinctions in consumption patterns, clothing and manner of living; rising levels of general education blurred the line between the educated and uneducated; mechanization and automation reduced the need for unskilled labour; large organizations produced a host of bureaucrats; taxation to support the social services which industrialism made necessary skimmed off some of the extra resources of the

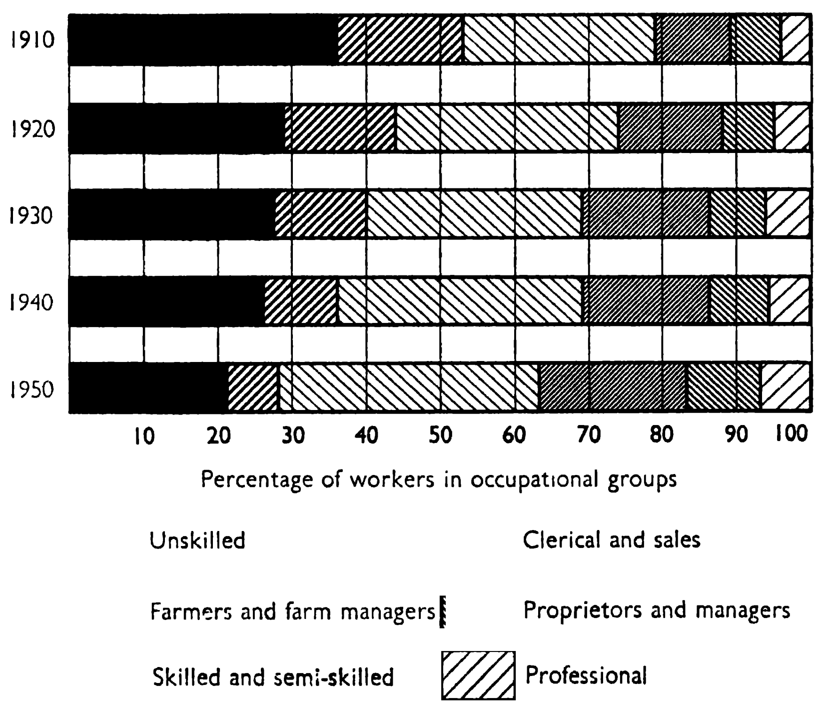


CHART VIII. Shift in Occupations, USA, 1910–50, percentage of workers in occupational groups.

Source: J. F. Dewhurst and Associates, *America's Needs and Resources*, 1955, pp. 730, 731.

rich, and pushed them closer to the general level; these same services raised still further the real incomes of the lower groups.[1, 2]

The trend may be clearly noted in the change in income distribution in Britain and in the United States. In Britain the highest income receivers at the opening of the century were receiving an estimated 1,500–2,000 times the amount received by the average industrial worker; in 1950 they received only 12–15 times the worker's income. Social expenditures, which involved for the most part a redistribution of real income, amounted to 18 per cent of national income in 1951 as compared with 5.5 per cent in 1913.

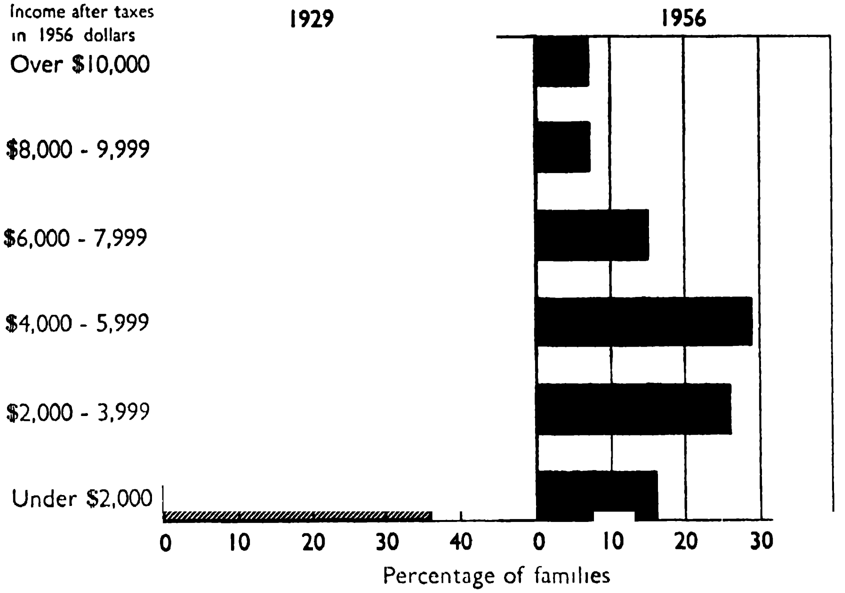


CHART IX. Distribution of Family Income in the USA, 1929, 1956 (percentage of families).
Source: Committee for Economic Development, *Economic Growth in the United States*, 1958.

In the United States the average income of the two lowest fifths of the population, before taxes, increased between 1935 and 1950 by 78 and 81 per cent respectively, while that of the top fifth increased by only 34 per cent and of the highest 5 per cent only 17 per cent. The income pyramid in the United States in 1955, even without adjustment for taxes, showed a concentration of incomes in the middle groups in marked contrast to the many very poor and few very rich typical of most non-industrial areas. The trend toward this type of income pyramid in all advanced industrial countries was so marked that it was sometimes referred to as a bloodless revolution.

With industrialization came the progressive urbanization of society. At the opening of the twentieth century there were only eleven cities of over 1,000,000 population; in 1950 there were 49 such cities or 63 if surrounding metropolitan areas as well as central city are included. The largest city at mid-century,

Tokyo, had more than twice the population of London in 1900, then the largest of the great cities. The number of urban centres with more than 100,000 people was approximately 280 in the earlier year and some 850 in the latter. Nearly 80 per cent of the population of England and Wales was already living in urban districts before the first world war. From a half to nearly two-thirds of the population in western European countries, the United States and Australia were urban dwellers at mid-century.

But figures of urban population tell only part of the story, for urbanization was not confined to the cities. Penetrated by arterial roads, served by electricity, equipped with farm machinery, reached by radio and motion pictures, rural areas lost their isolation and much of their distinctive character. In a broad sense the entire life of the industrial countries became urbanized.

The full meaning of this change for human life and society was a matter of great concern to teachers and scholars, statesmen and philosophers, parents and artists who tried to adapt themselves and to guide or lead others. Some, impressed with the age-long dependence of human beings on a small group of family or neighbours for their sense of belonging and source of values, thought that the rootless, heterogeneous impersonality of the city left the urban individual lonely, incomplete and without the means of developing his full personality. Others were concerned lest the multitude of forces beyond his control and the impact of information, ideas, values and opinions which did not grow out of his direct experience, should rob man of the independent judgment which he could exercise within the limited sphere of his former life and make him a follower and mirror rather than a master of his own thoughts.

Others, however, saw the city as providing a new, rich ground for human development, offering a wide range of fare to nourish the mind and senses and of contacts and experiences to enrich the personality. They thought that the new associations in trade unions, professional bodies, scientific circles, or with others of common interests, the new loyalties of broader scope, and the new opportunities to travel and observe offered the masses of men a chance to develop potentialities for which earlier societies had given no scope. Whether those who viewed the urban milieu with alarm or with hope had the truer insight, there was no doubt that urban industrialism was remaking the lives of a large and growing segment of mankind, as old relationships and old certainties gave way to new experience.

It was the impact of industrialization which pressed the state to assume new functions and expand its role—to protect its citizens against the insecurity of income which industry brought and the hazards of life for which the traditional extended family no longer offered a cushion; to cope with the practical problems of transport, utilities, health and safety which came with city living; to exercise a measure of control over powerful industries; to develop the facilities for education which industrial society required. As governments in industrial countries expanded their services to meet these

demands, they employed large and growing numbers of citizens and gathered through taxation a large part of the national wealth. Even in a country which retained a vigorous economy of private enterprise and consciously sought to minimize government activity, such as the United States, the number of civilian government employees, federal, state and local, mounted from 6·3 per cent of the total civilian labour force in 1930 to 10·5 per cent twenty-five years later, while the portion of the national income absorbed by taxation, including that used for military expenditures, rose from less than 10 to over 20 per cent. Canada more than tripled its civil service employees from 1925 to 1950. In countries more frankly devoted to the welfare state, the role of government expanded still further, and in those with state-directed economies the vast army of state employees came to include a large proportion of the citizenry, and most of the national income flowed through the hands of the state and its agencies.

In all fields industrialization brought large-scale organization that often overshadowed the individual. Gigantic corporations were matched by huge trade unions built up to bargain with them. Both organizations involved large bureaucracies. The individual participant in modern industry, whether he was a worker or a part of management, faced the central problem of how to maintain his sense of self in the midst of bigness—of the corporation, the trade union and the community in which he lived.

Modern industry also set its stamp on the intellectual, religious and artistic development of the time. It gave direction to much scientific investigation, both through support for research in its own establishments and as the industrialization of warfare led to heavy military expenditures in scientific fields. In addition, science depended on modern industry for the elaborate equipment and instrumentation indispensable to much advanced experimental research. In the social sciences, too, industrialism provided a powerful stimulus, for the problems to which modern sociology, psychology and human geography addressed themselves arose in large measure from the unsettling effect of the urban milieu, the breakdown of old values and the uncertainty in human relations which industrial society brought.

The challenge offered to philosophy and religion by the dominance of practical, rational and dynamically changing industrial forces was met by both adaptation and rejection. Dialectical materialism, pragmatism and logical positivism, in spite of their contradictory approaches to basic philosophical problems, were all expressions of the rational and practically oriented spirit of industrial society; secular defection from religion and modernism in religious dogma were their counterparts in the field of religion. But response to the impact of industrialism also found expression in the philosophy of existentialism with its psychological rejection of industrial society and often despair in the face of its problems; it also took the form of reaffirmation of religious orthodoxy or mystical religious faith.

In the arts new processes such as photography, new materials and new

industrial techniques put their mark on the visual arts and architecture, while mass audiences and mass production methods affected the nature and quality of literature, drama, screen and music. The artist in industrial society had to come to terms with its mass character or retreat into social isolation.

Industrialism thus transformed the societies which it came to dominate, reaching into every phase of life. By destroying old habits, old ties, old responsibilities and old certainties it created a mobile, changing, uncertain way of life. By opening wider horizons, creating new and broader relationships, breaking down barriers of distance and social class it set the stage for a new phase of human living. By lightening man's burden of toil and poverty it released immense human energy.

For the first time in human history a society of abundance became a reality, not merely the myth of a golden age or utopia. The first country to experience this new phenomenon, the United States, was clearly only the vanguard in mankind's movement toward this condition. The United States owed the priority of its abundance to a number of circumstances. It represented the projection of European civilization under the advantageous circumstances of a continent rich in resources. It had inherited and developed those European political, economic and social institutions which favoured full and rapid economic and social development, with a minimum of rigidity. These factors had combined to produce a high level of technology and organization geared to a large domestic mass market. In the twentieth century the United States was free from the destruction of war, yet was stimulated by wartime demands to achieve rapid advances in productivity. Similar conditions produced similar results in Canada, Australia and New Zealand.

In the 1950s it was already apparent that it was only a matter of a short time before many other countries of advanced technology would also become affluent societies. Britain and the countries of northern and western Europe were well on their way. Rapidly rising production and relatively slow rates of population growth brought *per capita* income in these countries by the end of the 1950s close to that of the United States a decade earlier and their levels of mass consumption were becoming similar. The main roads of Britain and the Continent were becoming as crowded with pleasure vehicles as those of North America. Japan exceeded all other countries in the late 1950s in the completeness of home electrification while a very high rate of economic expansion was raising levels of consumption in other lines. The USSR proclaimed its intention of outproducing the United States and it defined the communist society which it was approaching as a 'society of abundance'. The shape of abundance might vary substantially under the differing circumstances of different societies. But whatever the variations, the phenomenon as it actually appeared during these years was of immense historic importance in itself and of concern to mankind throughout the world.

II. CHANGE IN THE POSITION AND STRUCTURE OF NON-INDUSTRIAL SOCIETIES

It was the vision of this abundance, of the potentialities of industrialism for releasing human energies and opening up new possibilities for human development, that led the non-industrial countries to seek its benefits for their own societies, however long the road and however many the problems which would be encountered before the potential benefits could reach a large proportion of their populations. Whether in the radical, high-speed programme for China's great 'leap forward', or in the dedication of India to the task of modernization within the framework of traditional and liberal values, or in the aspiration of African peoples to bring themselves abreast of the new times, the elimination of man's poverty and the pursuit of abundance was the goal.

Many of these peoples had already experienced the impact of industrialism on their societies long before they began actively to seek its benefits. Wherever tea or rubber, indigo, tin, petroleum, jute, copra and countless other raw materials were produced, local societies had felt the effects of fluctuations in world markets, shifts in world demand and in the competitive position of different regions, changes in technology, and the impact of wars and depression. In addition the commercial products which reached their markets had often undermined local crafts and modified the balance of their economies even when the items involved, such as paraffin, thread or utensils, made up only a small part of local consumption. Twentieth-century industrialism accelerated the rate of social change and reached areas which had been largely untouched by the expansion of trade and investment in the preceding century.

The new means of transport and communication meant a breakdown of isolation, new possibilities for development, and a new importance for regions which had been inaccessible. From the time of the great European explorations the whole world had been linked by its seas, and the major centres of development had been in coastal areas. The coming of the railway had opened up the interiors of some continental regions and had linked them with the coasts; the opening up of the North American continent was associated with the introduction of the railways during the second half of the nineteenth century; the trans-Siberian railway was a factor in the penetration of Siberia; railways connected the interior of the Indian sub-continent with the port cities. But it was the highway, the motor car and the aeroplane of the twentieth century that were bringing the interior regions into new accessibility and new prominence—the vast interior of Asia where such ancient historic centres as Tashkent, lost during the era of the sea routes, flourished anew, or the region of Sinkiang which offered a new frontier rich in resources to populous China, or the interior of the South American continent, or the heart of Africa whose riches were only beginning to be unlocked in the middle of the twentieth century.

For some peoples, following their traditional ways, the new transport took away their functions and destroyed the basis of whole societies. Nomadic peoples of the west Asian and African deserts, whose camel trains had provided the transport and whose desert fighters had furnished the military forces of the areas, found themselves displaced by motor lorries and armoured tanks. With these new developments the last remnants of nomadism, once the way of life of many of the world's peoples, were disappearing from the face of the earth.

For the peasant village, which still at mid-century was the home of the majority of the world's inhabitants, the integrity of self-contained village life was fast breaking down. In varying degrees and with greater or less rapidity the mutual dependence of village members and their independence from the outside world was undermined from many directions—by the entrance of commercial goods to replace the products of village crafts, by the substitution of cash crops for subsistence agriculture, by the drift of workers from village to town, and by the coming of roads, education, radio communication and motion pictures to bring new people and ideas that had no place in the structure of village life. The individual, whose role had been defined and whose horizon had been bounded by the pattern of village relationships, gained alternative bases from outside the village society for his image of himself, his actions and his relations with his fellows. By mid-century the peasant village in nearly all parts of the world was no longer a complete and integrated society in itself, but a society in transition whose integration into the broader society that was emerging had not yet been achieved. Where governments were making conscious efforts to guide the transition they sought both to strengthen the village as a unit under the new conditions and to develop urban centres which would sustain the surrounding villages.

With the breakdown of isolation and of village integrity went the loosening of social relationships which had been part of the traditional structure of essentially static societies. The joint family was weakened everywhere, not only where it was under direct attack as in communist China but where, as in modern India, new legal structures favoured its dissolution as a legal entity, or wherever individualizing forms of economic opportunity drew its members into new relationships. The breakdown was most drastic in the detribalization of Africans who were drawn into mines or industries and whose entire structure of tribal relationships, values and controls found no place in the Europeanized urban society of which they formed the labour base.

Traditional bases of social stratification, by caste or other distinction which defined status, were modified. New classes of technicians or others whose position rested on their functional role in a changing society challenged the superiority of those who derived their position from a social system and tradition which was being replaced. With new political power, classes emerged which had never before enjoyed social or political status. Adult franchise identified the entire community with the state, and its exercise awakened

groups which had been submerged for ages and gave them both a vested interest and a manner of sharing power at all levels. This tendency was most conspicuous in India, in the rise of former 'untouchables' and members of lower castes through the operation of democratic processes which were used to further social and economic change.

By the middle of the century radical social and economic changes were thus under way and many old values had been undermined, while new values appropriate to the altered character of these societies were yet to take shape.

III. POPULATION CHANGE[3]

1. *Uprooted people*

In no previous period had such great numbers and so large a proportion of the people of the earth been uprooted from their ancestral homes and forced to find new homes and establish new relationships in an alien environment. The twentieth century might, indeed, be known as 'the century of the uprooted'. In the early decades the great stream of European immigrants who had first trickled and then poured from Europe to the New World since the seventeenth century rose to a flood. When the United States put up the bars and limited immigration after the first world war, the volume was sharply reduced, but some flow continued to North and South America and to Oceania whenever economic conditions offered favourable opportunities and war did not prevent movement. Many millions of Chinese migrated to Manchuria in search of economic opportunity. The movement of Russian population into Siberia, which was already considerable during the tsarist régime, was immensely stimulated by the development of great new industrial centres in this region of the USSR. Other movements of population in response to economic opportunity included the steady flow of Chinese to south-east Asia, of Indians to Malaya, Burma, East Africa and the Caribbean and of Africans from tribal areas into the mining regions of the Union of South Africa and the copper belts of the Rhodesias and the Congo.

The flow from farms or villages to the expanding metropolitan and industrial centres went on both within and between countries. Some workers migrated only seasonally or temporarily, such as the Polish and Italian workers who formed a large part of France's seasonal labour supply before the second world war, and the nearly half a million Algerians who worked in metropolitan France in the 1950s, intending to return home with their earnings. Especially in newly industrializing areas, workers tended to retain their village roots and to return, or at least to plan to return, after a period of earning in factory or mine. The labour force of African mines and mills at mid-century was still very largely composed of temporary workers whose place was taken after a period of months by others who also expected to remain for a temporary period. But for most migrants the transfer was complete and permanent, and the new and growing urban populations of industrial

and non-industrial countries alike were composed of people who had cut themselves off from their roots.

The most uprooting movement of people during these years, however, was not the drift of workers into areas of expanding economic opportunity but the tearing of people from their homes as a result of political and religious strife. The uprooting and resettlement of some 14,000,000 Muslims and Hindus at the time of the partition of India and Pakistan was the greatest single movement of people in a short time that the world had ever seen. But these were only the largest groups. The shift of Greek and Turkish populations in 1922 was followed by the exchanges of populations forced by Hitler in eastern Europe during the second world war. Refugees and expellees from revolution, civil war and oppression fled Russia after the October revolution, Germany and Italy during the Nazi and fascist régimes, Spain in the 1930s and eastern Europe after the second world war. To these movements must be added the flight to Palestine of Jews who survived the Nazi efforts at extermination, the displacement of nearly a million Arabs in the creation of the state of Israel, the repatriation of several hundred thousands of Turks from Bulgaria in the 1950s, and the flow of nearly a million refugees from North to South Vietnam when the French were forced to withdraw and the country was partitioned in 1954. All these and lesser movements elsewhere made the displaced person a twentieth-century type. The problems which he presented and the attitudes which he brought from his experiences became important elements in the outlook of the period.

2. *Mounting numbers*

The most dramatic feature of the world's population was the speed-up in its rate of growth. In the first half of the century, in spite of wars of unprecedented destructiveness and one of the most fatal epidemics of modern times, the influenza epidemic of 1918, the annual rate of increase in the number of people was nearly half again as great as during the last half of the nineteenth century and nearly twice that of a hundred years before. Yet by the decade of the 1950s the growth since 1900 appeared slow, for the rate had jumped to almost double the average for those fifty years.

In earlier periods of the world's history upward spurts in population had come with expansion in the means to sustain life. In the twentieth century they reflected the new means to postpone death. As modern medicine developed the capacity to control or prevent one disease after another, it raised the survival rate and extended the life span of those whom it reached. Until the second world war its major impact was on the industrially developed countries whose death rates declined steadily, creating a wide disparity between the life expectancy of their citizens and those in underdeveloped areas. But in the years after the war modern medicine penetrated to most areas where death rates had remained high, dramatically wiping out ancient scourges such as malaria, sharply reducing infant mortality and radically altering the

balance between births and deaths. Death rates plummeted while birth rates stayed high, and countries such as Mexico faced the prospect that their populations might double in a mere twenty years.

The reduction in death rates in the industrially developed countries brought only a moderate acceleration of population growth, for the process was gradual and it was accompanied by a decline in births as the rational attitudes characteristic of industrial society were extended to family planning. Possessing ample and expanding economic resources and social institutions, these countries faced no serious problems in feeding, educating, employing and housing their growing numbers; in fact several of the European countries during the inter-war period were more concerned with their low birth rates and slow population growth than with the reverse. For them the principal result of the lowered death rates was to change the age composition of the population and convert the aged few into a large body of senior citizens. This was a change of considerable social and cultural importance but it was not disruptive and, even when higher birth rates brought new increases after the war, the impact was absorbed for the time being at least, though not always without difficulty, especially in housing and the expansion of educational facilities.

But in most non-industrial and partially industrialized areas rapid population growth presented grave problems. The most immediate difficulties arose where there was already pressure on the land, as in the Nile valley, Java, parts of China, India and Pakistan, the Andes, and where traditional methods of agriculture and small subsistence farms could not sustain additional numbers. In such areas increasing rural poverty set in motion a migration to the cities which exceeded in volume the available urban jobs, produced a large body of unemployed or semi-employed people and created a massive demand for housing, education and other facilities. Even where empty lands awaited settlers and ample resources could sustain a much larger population in the future, as in Brazil and some other parts of South America, the situation was not simple; for the number of new children to be educated, families to be housed and workers to be employed placed a heavy strain on existing resources and called for a rate of economic expansion and degree of institutional adaptability most difficult to achieve. Ever-increasing numbers threatened to undermine the determined efforts to reduce illiteracy and poverty and the steps designed to create the economic momentum which alone could convert the additional people from a burden to an asset. The situation was a precarious one, for unsuccessful attempts to satisfy the demands for services which modern peoples everywhere had come to regard as their due could not only impede economic development but imperil political stability as well.

For the world as a whole the prospect of greater and greater numbers on what seemed like a shrinking globe, and the differential rates in different parts of the world, made the population problem a live issue for the first time in world history.

IV. NEW CULTURAL ORIENTATIONS

With these changes in social structures and relationships went changes in attitudes and cultural orientations. Western man had to learn to see himself, not as standing at the pinnacle of human development, but as one among many peoples, each with its own cultural integrity and dignity, and its own right and ability to demand respect. Eastern societies derived new attitudes from their contact with the West, and these attitudes in turn became part of the dynamics of their own development.

The most radical concept which penetrated eastern societies was the doctrine of change. In Asian countries generally, the accepted view of society was of a stable condition based on immutable principles and unchanging institutions. Change meant decline, a fall from moral standards, and was therefore to be resisted at all costs. This was so marked a feature of Asian life that reformers had always taken the greatest possible care to insist that they were not demanding anything new but were calling for a restoration of something lost.

But from the early twentieth century the young men who returned from their higher studies in western universities to provide intellectual leadership in the emerging national movements in Asia made the principle of change an article of faith. The scientific approach to such daily problems as public health and sanitation brought home to the ordinary man the idea that change can be a normal feature of human life. More than merely accepting change, moreover, Asian societies began to conceive of the possibility of progress. For example, while the Hindu sacred text, the *Gita*, had taught a doctrine of continuing social adjustment, and the Buddha had preached the doctrine that all things change, it was only when these ancient teachings were re-examined in the context of the western idea of progress that they were seen as containing the idea that change is the basis of life.

When change came to be accepted as desirable and progress became an ideal, time acquired a new importance. In generally stable societies the time factor was not a major consideration; the joint family was a continuous institution and as a result the urge for achievement or for quick results was not great. The breakdown of the joint family combined with other influences to change the idea of time, for the family head of the single family unit had a direct responsibility for the welfare of the immediate group. A more competitive approach to life, a sense of urgency and a desire to achieve provided new motivations to individuals.

One dimension of time was a new historical sense which developed as European scholars delved into Asian history and Asian students turned to the discovery of their own past. The first effect of the world consciousness that was already being awakened before the end of the nineteenth century was to show Asians to themselves in an inferior world role. But as the work of European scholars brought to light evidence of the peoples who had built

empires, established colonies and spread their cultures through trade and travel, Asian peoples were able to develop a self-image which could undergird their nationalism with the reality of their own pasts.[4]

The political nationalism which successfully challenged western hegemony thus became at the same time a revival of national cultures. The reassertion of cultural traditions took the form of revitalizing traditional religions, renewing interest in traditional arts such as the dance and in local languages and literatures, and rescrutinizing the traditional values of the society. At times it was a conservative revival, often led by the most orthodox religious element, which sought to re-establish traditional forms of authority and modes of life in the face of influences which were bringing change. More often it expressed efforts to relate the modernization of society to the vital and positive elements which had come from the past.

At the other end of the scale, attitudes toward the individual and toward human life also underwent fundamental change. The notion of human equality was alien to the traditions of eastern societies; yet by the time that these countries achieved political independence they were ready to write into their constitutions the principles of democratic equality, majority rule and, generally, universal suffrage, including suffrage for women. Though these principles had rarely been fully assimilated, their mere enunciation marked the change in outlook which had taken place by the middle of the twentieth century.

In the attitude toward life itself, the old fatalism and the dependence on religious practices, charms, special offerings or prayers to cure illness and ward off misfortune were yielding nearly everywhere before the demonstrated efficacy of modern medicine. The almost universal demand for doctors and hospitals reflected the new view.

Thus the scientific approach to life, the basis for the transformation of the industrial societies in these years, was entering into the outlook of the non-industrial societies as well, to point the direction of their development in the years ahead.

NOTES TO CHAPTER V

1. Professor László Zsigmond points out that it is impossible to agree with the authors' assertion that in 'modern industrialism' the differences between the various classes of the population are tending to disappear, and that with the disappearance of a clearly-marked contrast between wealth and poverty a majority of the population comes to consist of members of the so-called middle classes. This is a mistaken assumption that has no basis in actual fact. Dr János Jemnitz agrees with Professor Zsigmond and remarks that the term 'middle class' as used in this work is too vague and imprecise. It can cover the technical intelligentsia, managers and technicians—social groups which cannot all be considered as belonging to one and the same class. . . . We note that such professional groups as engineers, lawyers and bankers are lumped together (as the uppermost section of the middle class). This classification is superficial. The rise in the living standards and cultural niveau of the working class leads the authors to suppose that class divisions are tending to lessen, since in their view the working class is rising to the level of the middle class. This problem undoubtedly merits closer analysis than is given in the present work. Attention should be paid to such factors as the role of property as a link between members of a particular group, sources of income, and class relationships. If the latter are taken into account, it becomes impossible to speak of 'the disappearance of classes'. Doctor of Philosophical Sciences V. S. Semenov points out that the theory that the growth of the 'middle class' represents a 'new path' of transition from capitalism to a classless society is fundamentally anti-scientific. It is based on the concept of 'social stratification', and proceeds from the premise that social groups are to be distinguished by secondary and derivative characteristics: ideas, outlook, psychological attitudes, education, spiritual culture, biological characteristics, way of life and behaviour, nature of employment, level of income, and role in the organization of the labour process. This approach disregards the decisive and basic attribute of social classes: men's relationship to the means of production. The very term 'middle class' is exceedingly imprecise. In 1949 Harry Truman, President of the USA, declared that the American 'middle class' comprised individuals and families with earnings of 10,000 to 25,000 dollars a year. Included in the 'middle class' were officers, members of the free professions, some wealthy farmers (i.e. capitalists), 'administrative personnel and self-employed persons' (small property-owners, artisans, owners of shops and the like), office and commercial employees, and a large segment of the skilled workers. At the present time many American sociologists and government bodies include in the 'middle class' from 60 per cent to 80 per cent, or more, of the US population, thereby embracing the greater part of the working class and a sizeable element of the capitalist class.

   The Danish sociologist J. Havemann considers all skilled workers members of the 'middle class'. The British labour theoretician G. D. H. Cole assigns to the 'middle class' members of the most varied social groups, from entrepreneurs (except the largest) to shop-assistants and typists.

   The German sociologist Helmut Schelsky (Federal Republic of Germany) assigns to the 'middle class' everyone who accounts himself a member of this class, irrespective of his actual social position (see H. Schelsky, *Die Wandlungen der deutschen Familie in der Gegenwart*, Hamburg, 1954).

   It is impossible to concur in the view that the 'middle class' is tending to swallow up gradually all other classes of the population. Thus, for example, the urban and rural petty bourgeoisie, employees and intelligentsia, taken together, formed the following percentage of the working population of the USA in the years stated:

1870	1910	1950	1954
47·2%	43·2%	43·5%	44·1%

   (Third World Congress of Sociology, *Transactions*, Vol. III, p. 70; J. A. Kahl, *The American Class Structure*, New York, 1957, pp. 13, 67). The thesis that with the growth of the 'middle class' income differences disappear also does not accord with the facts.

   It is characteristic that in his address to the Third World Congress of Sociology the American scholar Kurt B. Mayer stated that 'the image of America as a society where

"everybody is middle class" has persisted long after it ceased to be in accordance with economic and social reality' (Third World Congress of Sociology, *Transactions*, Vol. III, p. 71).

2. *The Author-Editors explain the sense in which they have used the term 'middle class' as follows:*

In using the term to refer to the relative expansion in the portion of the population which has substantial access to the fruits of production, enjoys corresponding aspirations and patterns of living, and engages in occupations which require education and carry responsibility and some prestige, they have chosen to use the term in its common, imprecise sense to apply to essentially imprecise phenomena.

'Class' may be defined in a number of ways. The term always implies position on a scale from lower to higher, but it may be limited to economic position, applied primarily to social position, or used in a more general way to designate status within a society; it may be based on stratification in relation to occupation, income, consumption, education, social recognition or prestige, power. The relevance of one or another factor to what is happening to class structure depends on the definition. If 'class' is defined in terms of relationship to the means of production, i.e. limited to economic relationships and, within these relationships, to the factor of power, it is irrelevant to consider such factors as actual levels of real income, disparity or lack of disparity in income, similarity or dissimilarity in levels of living, or occupational patterns. If 'class' is defined in terms of social strata and standards of living, however, such factors are of central importance.

The Author-Editors have chosen to use the term in a broad socio-economic sense which includes all of the factors mentioned above. In so doing, they are taking no position as to how the term should be used in other works.

Evidence of the tendency for the middle class, in the sense used in the text, to expand may be seen in the following trends in occupations, income distribution, and relation between the earnings of industrial and professional workers in the United States:

OCCUPATIONAL DISTRIBUTION OF EMPLOYED PERSONS IN THE UNITED STATES—1900–60
Per cent

	1900	1910	1920	1930	1940	1950	1960
Professional, technical and kindred workers	4·1	4·7	5·4	6·8	7·5	8·6	11·2
Farmers and farm operators	20·0	16·5	15·2	12·3	10·4	7·5	4·2
Managers, officials and proprietors, except farm	5·9	6·6	6·6	7·4	7·3	8·8	10·6
Clerical and kindred workers	3·1	5·4	8·0	8·8	9·7	12·2	14·7
Sales workers	4·5	4·7	4·9	6·4	6·6	7·0	6·6
Craftsmen, foremen and kindred workers	10·7	11·5	13·0	12·9	12·0	14·2	12·9
Operatives and kindred workers	12·7	14·5	15·7	15·8	18·4	20·3	18·0
Private household workers	5·5	5·1	3·3	4·1	4·6	2·5	3·3
Service workers except private house-workers	3·5	4·6	4·5	5·8	7·1	7·8	9·1
Farm labourers and foremen	17·6	14·4	11·8	8·8	6·9	4·4	3·9
Labourers, except farm and mine	12·4	12·0	11·6	10·9	9·5	6·7	5·5
	100·0	100·0	100·0	100·0	100·0	100·0	100·0

Source: US Department of Commerce, Historical Statistics of the United States, *and* Statistical Abstract of the United States, 1964.

REAL FAMILY INCOME OF FAMILIES AND UNATTACHED INDIVIDUALS IN THE UNITED STATES
(in 1954 dollars)

	Income after Income Taxes (percent. distribution)					*Income before Income Taxes (percent. distribution)*				
	Under 2,000	*2,000–4,000*	*4,000–6,000*	*6,000–10,000*	*Over 10,000*	*Under 2,000*	*2,000–4,000*	*4,000–6,000*	*6,000–10,000*	*Over 10,000*
1929(1)	35·8	38·9	13·5	7·6	4·2	35·8	38·9	13·5	7·6	4·2
1935–6(	42·2	33·8	14·2	6·6	3·2	42·2	33·8	14·2	6·6	3·2
1941						30·8	31·3	21·5	12·1	4·3
1947						19·3	32·3	24·9	16·6	6·9
1950	20·7	32·8	26·4	14·9	5·2	19·8	30·5	25·7	17·4	6·6
1955	16·9	28·0	28·5	19·1	7·5	15·9	25·4	26·2	23·1	9·4
1960	15·7	24·9	25·7	23·1	10·6	14·8	22·4	23·5	25·8	13·5
1962	14·8	23·6	25·0	24·7	11·9	13·9(2)	21·2	22·6	27·0	15·3

	Average Income after Taxes	*Average Income before Taxes*
1929	$3,791	$3,791
1935–6	3,343	3,343
1941		4,161
1947		4,877
1950	4,526	4,943
1955	5,070	5,618
1960	5,570	6,193
1962	5,815	6,490

Percent. Increase in Real Income after Taxes
1935–36 to 1962

Families in:	%
Lowest Fifth	112
Second Fifth	127
Third Fifth	85
Fourth Fifth	100
Highest Fifth	48

Source: US Department of Commerce, Survey of Current Business, *April 1964.*

(1) *In 1929 and 1935–6, personal income taxes were low and no figures for after-tax income are available. The before-tax figures have been included in the after-tax columns as substantially representing the after-tax distribution. The first year for which after-tax figures are available is 1950.*

(2) *It should be noted that over half of the families and unattached individuals with incomes (in 1954 dollars) of less than $2,000 in 1962 were unattached individuals such as young persons entering the labour market, older persons leaving the labour market and working only part time, etc.*

AVERAGE ANNUAL EARNINGS OF MANUFACTURING PRODUCTION WORKERS, PUBLIC PRIMARY AND SECONDARY SCHOOL TEACHERS, COLLEGE (UNIVERSITY) TEACHERS, AND ENGINEERS IN THE UNITED STATES. 1929–1954

	Manu-facturing Production Workers(1)	*School Teachers*	*College Teachers*	*Engineers*(2)	*Ratio of Earnings of Manufacturing Production Workers to Earnings of:* *School Teachers*	*College Teachers*	*Engineers*
	$	$	$	$	%	%	%
1929	*1288*		*3056*	*3468*		*42·1*	*37·1*
1930	*1196*	*1420*	*3065*		*84·2*	*39·0*	
1931	*1073*		*3134*			*34·2*	
1932	*878*	*1417*	*3111*	*2820*	*61·9*	*28·3*	*31·1*
1933	*866*						
1934	*966*	*1227*		*2520*	*78·7*		*38·3*
1935	*1035*		*2666*			*38·9*	
1936	*1121*	*1283*	*2732*		*87·4*	*41·0*	
1937	*1239*		*2843*			*43·6*	
1938	*1148*	*1374*	*2861*		*83·5*	*40·4*	
1939	*1229*			*3324*			*37·0*
1940	*1298*	*1441*	*2906*		*90·3*	*44·7*	
1941	*1533*						
1942	*1907*	*1507*	*2914*		*126·5*	*65·4*	
1943	*2240*		*3039*	*4008*		*73·7*	*55·9*
1944	*2376*	*1728*	*3331*		*137·5*	*71·3*	
1945	*2298*		*3277*			*70·1*	
1946	*2253*	*1995*	*3465*	*4884*	*113·0*	*65·0*	*46·1*
1947	*2557*		*3736*			*68·4*	
1948	*2762*	*2639*	*4123*		*104·7*	*67·0*	
1949	*2802*		*4234*			*66·1*	
1950	*3033*	*3010*	*4354*		*100·7*	*69·6*	
1951	*3294*						
1952	*3492*	*3450*	*5106*		*101·2*	*61·3*	
1953	*3664*			*6216*			*58·9*
1954	*3665*	*3825*			*95·8*		

Source: US Department of Commerce, Historical Statistics of the United States, *and US Department of Labour,* Employment and Earnings Statistics for the United States, 1909–62.

(*1*) *Based on average weekly earnings.*

(*2*) *Based on median monthly salary rates.*

3. Professor E. N. Anderson notes that:

'The treatment of population in this chapter and in Chapter XV is open to the criticism that it minimizes the impact of catastrophic events in the period—the enormous losses through war, revolution, famine and forced migration—and, further, that it fails to discuss the role of migration, not merely in Europe but in Asia as well, as an instrument of population adjustment and its relation to economic conditions and social and political tensions. It is to be noted that, in spite of tremendous loss of life in World Wars I and II, the deficit in Europe and Russia in manpower was soon overcome by natural increase, and there was no absolute decline, apart from the gap in the number of births during the war years, in the population of these areas.'

For further discussion consult:

Dudley Kirk, *Europe's Population in the Interwar Yeats* (League of Nations, 1946).

Eugene M. Kulischer, *Europe on the Move: War and Population Changes, 1917–1947* (New York, 1948).

Bruno Lasker, *Asia on the Move* (New York: Institute of Pacific Relations, 1945).
Ministry of Information and Broadcasting, India, *Millions on the Move: The Aftermath of Partition* (Delhi, 1949).
Joseph Schechtman, *Postwar Population Transfers in Europe 1945–55* (Oxford, 1962).
Joseph Schechtman, *On Wings of Eagles* (New York, 1961).
Joseph Schechtman, *Population Transfers in Asia* (New York, 1949).
H. J. Wiens, *China's March toward the Tropics* (Hamden, Conn., 1954).

4. Candidate of Juridical Sciences E. A. Bovin notes that it is not ideas that make history, but history that makes ideas. The awakening and consolidation of a sense of nationality has its roots primarily in actual social-economic processes (the formation of capitalist relations and the emergence of a national bourgeoisie).

PART ONE

THE DEVELOPMENT AND APPLICATION OF SCIENTIFIC KNOWLEDGE

SECTION ONE

NEW SCIENTIFIC THOUGHT

CHAPTER VI

THE NEW SCIENTIFIC THOUGHT AND ITS IMPACT*

THE most creative cultural development of the twentieth century was the emergence of a new scientific outlook and its impact on the thought and life of mankind.

Beginning at the opening of the century, scientists conceived a new view of nature and her laws which made as sharp a break with the thought which preceded it as the scientific inquiries of the sixteenth and seventeenth centuries had made with the thought of the Middle Ages.

The new scientific thought may appropriately be termed the second scientific revolution. The first great scientific revolution had evolved the scientific method of inquiry. Looked at from the perspective of the twentieth century the unfolding of scientific thought between 1500 and 1700 appears critical in the creation of modern civilization. According to one contemporary historian, Professor Herbert Butterfield, it 'outshines everything since the rise of Christianity and reduces the Renaissance and Reformation to the rank of mere episodes'.†

The first scientific revolution was an intellectual revolution; it taught men to think differently. Only later was this thought put to a new kind of practical use, in the industrial developments which gave modern civilization its outward character. By the end of the nineteenth century the scientific method had not only brought profound changes in outlook; science was remaking the world, root and branch.

The second scientific revolution, too, began as an intellectual revolution. About the year 1900 the view of nature which the first scientific revolution had established began to exhaust its successes and to meet its first failures. Delicate new phenomena were found here and there which the established view of nature and her laws could not unravel. As a result scientists began slowly and with many hesitations to form a new conception of the processes of nature and a new assessment of scientific activity itself. The shift in outlook was subtle but it went very deep.

Like its predecessor the second scientific revolution spread slowly from the minds of the specialists who conceived it. In the course of fifty years its practical consequences reached far; many of the spectacular applications of science in the years following the second world war grew out of the new

* This chapter was prepared by Dr. J. Bronowski.

† Herbert Butterfield, *The Origins of Modern Science* (G. Bell & Sons Ltd, London, 1950), p. viii.

concepts and the new approach. In time it began to transform the outlook of the layman as well as the scientist and to enter the minds and affect the lives of people in all parts of the world.

I. THE STATE OF KNOWLEDGE IN THE 1890S

The character of the revolution in scientific thought can only be understood against a background of the knowledge and thought at the end of the nineteenth century.

1. *Physical sciences*

In most respects the physical sciences seemed in the 1890s to have reached almost the frontiers of knowledge. There existed a coherent theory of the structure of matter which explained the known phenomena. According to this theory all matter consists of atoms, which form a regular arrangement when matter is in the solid state, but become progressively more loosely held together when matter passes into the liquid and then into the gaseous state. About eighty essentially different kinds of atoms were already known. These were known chemically to fall into cyclic groups, with marked similarities of physical and chemical activity in any one group. But nothing was known or conjectured which could explain either the differences between atoms of one kind and those of another, or the similarities among the different kinds of atoms which belong to one cyclic group.

Since the atoms were conceived, as the Greeks had named them, indivisible, there was indeed no sense in which either their differences or their likenesses could be discussed. For to explain a material difference one must presumably point to some underlying difference either in make-up or in arrangement. An indivisible atom would have neither make-up nor arrangement. On this view each kind of atom is a fundamental entity, complete and self-contained; its properties could be described but they could not be traced back to any deeper underlying principles.[1]

The different kinds of atoms were known to combine in many different chemical structures. Descriptive laws had been found which pictured how the atoms in such structures fit together. It had been guessed that the atoms of sodium and chlorine, when they combine chemically to make table salt, hold each other in place by occupying the corners of a cubical lattice. It had been deduced that in some hydrocarbons the carbon atoms form long, open chains, and in others they are linked, six at a time, in closed rings.

These pictures of chemical structures had proved themselves to be powerful guides to discovery, particularly in the study of carbon-containing substances which run through all the processes of life. They had already made it possible to synthesize many new substances. Nothing was known however of the forces which are presumably at work when atoms are held together in such stable structures.

Scientists recognized of course that the physical world does not consist

simply of matter but also of forces between the pieces of matter and of radiations which pass from one piece of matter to another. Of the known forces the most important historically remained the force of gravitation which Isaac Newton (1642–1727) had first conceived to spread from every piece of matter throughout all space. Newton had thereby with one stroke brought order and understanding into the motions of all the heavenly bodies, and his achievement seemed as supreme in 1890 as on the day that the *Principia* had been published, in 1687. Earlier in the nineteenth century, when the distant planet Uranus seemed not to be keeping time, the astronomers John Couch Adams (1819–92) in Britain and Urbain Jean Joseph Leverrier (1811–77) in France had calculated what lesser planet must be disturbing it. Working with no knowledge of one another and with nothing but pencil, paper and Newton's laws, each calculated where such a planet must be. And sure enough, when the great telescope at Berlin had been turned to the spot calculated by Leverrier, there had been Neptune clear to the eye, and spectacular in its vindication of Newton's laws.

Also known were the forces of electricity and of magnetism, and it was now established that each could induce the other. Moreover, James Clerk Maxwell (1831–79) in the 1860s had given theoretical reasons for believing that such a radiation as light might be an electromagnetic disturbance propagated through space. If this was so then electromagnetic disturbances might well create other forms of radiation which had not been detected hitherto, and the young Heinrich Rudolf Hertz (1857–94) had just produced new radiations of this kind; they later turned out to be the radio waves. New radiations were also detected in 1895 by Wilhelm Konrad von Röntgen (1845–1923) which came to be called X-rays. It was becoming clear that visible light covers only about an octave in the range of electromagnetic radiations, and that the range extends for many octaves on either side, up from the ultra-violet to the short X-rays, and down from the infra-red to the long radio waves.

The question remained as to what carries these electromagnetic radiations from one point to another. Sound was known to be a physical disturbance of the air; it is propagated in the air and it is the air which carries its waves from point to point, and indeed forms them. If the air is pumped out of a hollow glass ball no sound can cross it. Yet light still crosses it. What carries the light waves? And what carries the other electromagnetic radiations, of which light is only one waveband to which the human eye happens to be sensitive?

To this question the nineteenth century answered: the aether. This was the universal medium which scientists posited to carry the different radiations through space. Thus the aether was thought to carry light from the stars to us, and the warmth of the sun on which our lives depend. It had in fact to carry from place to place all that energy which is not directly transmitted by the movement of matter. To do this, however, it turned out that the aether as a transmitter of energy had to have extraordinary and in many ways contradictory properties quite unlike those of any known material. For this reason

the aether was the outstanding puzzle to scientists at the end of the nineteenth century.[2, 3]

2. *Mathematics*

There had been striking extensions in the field of mathematics, the discipline upon which the physical sciences always leaned heavily and to which they owed much of their success. Although in Britain mathematics had been particularly concerned with problems relating to mechanics and physics, on the continent of Europe pure mathematics had reached new levels. The non-Euclidean geometries had been discovered. Rigorous methods had been found to discuss infinitesimal and infinite quantities. It had been shown that the distinction which the Greeks had known, between numbers which can be written as fractions and those which cannot, can be further refined; it is possible to give precise definitions of numbers, for example the ratio between the circumference of a circle and its diameter, which cannot be expressed by any algebraic equation at all. A whole field of work was opened in the study of new functions and the application to them of mathematical processes which hitherto had been confined to linear spaces. New methods had been found for attacking some of the beautiful problems in the theory of numbers.

To both the pure and the applied mathematician in the latter part of the nineteenth century, however, mathematics remained at bottom an affair of measurements and therefore of numbers. Their cast of mind might be epitomized by a remark attributed to the German mathematician L. Kronecker (1823–91): 'God made the whole numbers: everything else is the work of man.' The basic numbers, the whole numbers, were something that had to be taken for granted; they were, in a sense, God-given.[4]

3. *Biology*

The great upheaval in the nineteenth century had been in biology, as a result of the publication in 1859 of *The Origin of Species* by Charles Darwin (1809–82). Darwin's achievement was twofold. He marshalled a vast body of evidence supporting the theory that evolution had occurred, and he discovered a scientifically acceptable mechanism for its occurrence.

The argument for evolution was reinforced by the discovery at about the same time of the unit common to all living forms, the cell. One living creature differs from another in the number of cells set aside for different uses and in the complexity of their organization. But, as Theodor Schwann (1810–82) established in 1839, all are built from cells, and basically therefore all can be pictured as different assemblies from the same units.

Darwin's development of the principle of natural selection was as important for biology as were Newton's *Principia* for mechanics and astronomy, though in a different way. It made the variety and development of life scientifically comprehensible. All organisms are variable, and some of the variation is heritable. Artificial selection by man can accumulate desirable heritable

variations to produce new breeds. In nature there is overproduction of offspring, and therefore a struggle for existence.[5, 6] Individuals with favourable heritable variations will tend to survive in greater numbers. A species can therefore change gradually in the course of generations. Darwin called this principle of the differential survival and reproduction of favourable heritable variations natural selection.

The weakness of Darwin's theory of evolution by natural selection lay in the absence of a science of genetics—the mechanism by which variations arise and heritable characteristics, including new variations, are transmitted.[7]

The nineteenth century had discovered that all existing life arises from pre-existing life—i.e. that life is self-reproducing matter; that most known forms of life consist of cells containing an organized nucleus; that most growth entails the division of cells, including the accurate division of the nuclear system; that reproduction in single-celled organisms is by division of cells, in multicellular organisms by detached single cells or groups of cells.

In sexual reproduction the nuclei of two detached single cells unite. But it was still widely believed that this involved some sort of blending or fusion of whatever was transmitted. If so, the offspring of a cross would become progressively less differentiated and heritable variations would tend to disappear. This dilemma was not recognized as having been resolved until after 1900. Meantime, however, granted the undoubted fact that variations do occur and that some are heritable, natural selection remained a valid principle. Much of later nineteenth-century biology was devoted to reinterpreting biological facts in its light.

Classification, comparative anatomy, embryology and other old divisions of biology became transformed by the hypothesis of evolution. But the impact of Darwin's work was far more extensive than within the limits of the old biology itself. Perhaps no single discovery since Copernicus produced an impact of such force as did Darwin's on all those fields of science and philosophy which touched on the position of man in the universe. Recognition of the fact that man is subject to the same biological laws as other organisms and can no longer consider himself biologically apart from them led not only to the breakdown of old religious beliefs but also to the development of new philosophical doctrines and to many new psychological insights.

4. *Social sciences*

The social sciences in their empirical form had hardly come into being by the 1890s. The French philosopher Auguste Comte (1798–1857) had insisted that the positive method of thought which characterized the natural sciences was the highest stage of human reason and must be applied to human behaviour through the scientific study of sociology. But although his positivist principles gained wide popularity they produced few attempts to determine the workings of society from examination of the social data which were beginning to be accumulated. The careful collection and objective scrutiny of

evidence in the social field had been carried furthest by the school of scientific historians which had been developed in the German universities and had spread thence through Europe and America. Anthropologists had only begun to analyse systematically the observations of the customs of primitive peoples recorded by travellers, missionaries and colonial administrators and had not developed their own techniques for observing these fast-disappearing social forms.[8] The first attempt to survey social life in a modern city, Charles Booth's *Life and Labour in London*, was undertaken in 1890.[9]

A considerable body of social theory had however been formulated in the effort to describe and predict social phenomena. Economic theory purporting to explain economic behaviour under conditions of competitive capitalism had been elaborated during the nineteenth century on the foundation laid by Adam Smith's *Wealth of Nations* (1776) and the eighteenth-century assumption that human motivation is rational. Economists on the European continent and in America built up a picture of the operation of an economy governed by the law of supply and demand, where the essence of economic relationships is an exchange in which each seeks to maximize his advantage and minimize his cost, and in which supply and demand are equated by a flexible price; they developed a system of mathematical equations in which to express the totality of these economic relationships. In this view of society, which provided the rationale for a *laissez-faire* policy on the part of government, self-seeking by each individual would furnish the motive power for the economy, bring continuous economic progress and convert the advantage of each into the good of all.

An alternative body of theory, developed by Karl Marx (1818–83), arrived at a different estimate of the results of self-seeking in a capitalist economy. Focusing his attention on the process of production and the relation of employer and employed in the factory system, he saw capitalism leading, not to continuous economic progress, but to progressive disparity between the capitalist exploiter and proletarian worker and to successively severe economic crises. Following on the one hand the German philosopher Georg Wilhelm Friedrich Hegel (1770–1831), who viewed historical development as a dialectical process of struggling opposites which he saw as the self-deploying of the World Spirit, and taking on the other hand the view that not spiritual but material factors are dominant to human motivation, Marx formulated dialectical materialism as a concept of historic development and predicted that class struggle will lead to eventual revolution and the ultimate creation of a classless society.[10]

Other social theorists applied the theory of evolution to the analysis of society. In the hands of Herbert Spencer (1820–1903) the concept of the survival of the fittest reinforced the conclusions of the *laissez-faire* economists and justified the position of those individuals or peoples who rose to wealth and power in the competitive struggle. Anthropologists assumed that societies passed through stages of evolution from lower to higher states and that

primitive societies were survivals from states through which more advanced societies had already passed.

The alternative formulations of the nature of society had in common an assumption of progress, whether through the process of competition, dialectical materialism or evolution from lower to higher stages of civilization.

With respect to the psychology and behaviour of individuals much of the evidence on which theories were based had been drawn from the introspection of philosophers. The concept of the human organism as a mechanism which responded to stimuli, borrowed from the mechanistic conceptions of the physical sciences, led Wilhelm Wundt (1832–1920) at Leipzig and his pupils in Europe and America to undertake psychological studies of stimuli and response in an experimental approach to the understanding of human behaviour. On the further assumption that physical differences were associated with qualities of character, intelligence and higher or lower development, some sociologists attempted to establish the existence of criminal types and physical anthropologists looked for evidence of racial characteristics. The French sociologist Émile Durkheim (1858–1917) made a beginning in the 1890s toward the study of group psychology by examining the process by which the interactions of individual consciousnesses produce syntheses in the form of religious beliefs or value judgments that carry authority because of their collective character.

II. THE OUTLOOK BEFORE 1900

Underlying scientific knowledge and thought in all areas ran several strong common assumptions. Almost all thought conformed to four basic preconceptions, or unspoken ways of looking at nature, which at once reflected and directed the thought of the age.

First was the principle that nature proceeds by a strict chain of events from cause to effect, the configuration of causes at any instant fully determining the events in the next instant, and so on for ever. This principle of determinism, of cause and effect, left no uncertainty in nature.

Apparent uncertainty was presumed to be the reflection of ignorance; if there were full knowledge, it would always be possible to predict the future precisely. This had been said explicitly by the French mathematician Pierre Simon Laplace (1749–1827) in a famous passage. If we were given, said Laplace, the whereabouts and the speeds at this instant of every atom in the universe, then we should be able to forecast their whereabouts and speeds at every instant afterwards. We could therefore predict without the smallest uncertainty the fate of the entire universe, its molecules and its men, its nebulae and its nations, from now into eternity. Indeed we could do more than this, because we could go backward in time as well as forward and reconstruct the past also to eternity.[11]

With the principle of determinism was coupled a second principle which

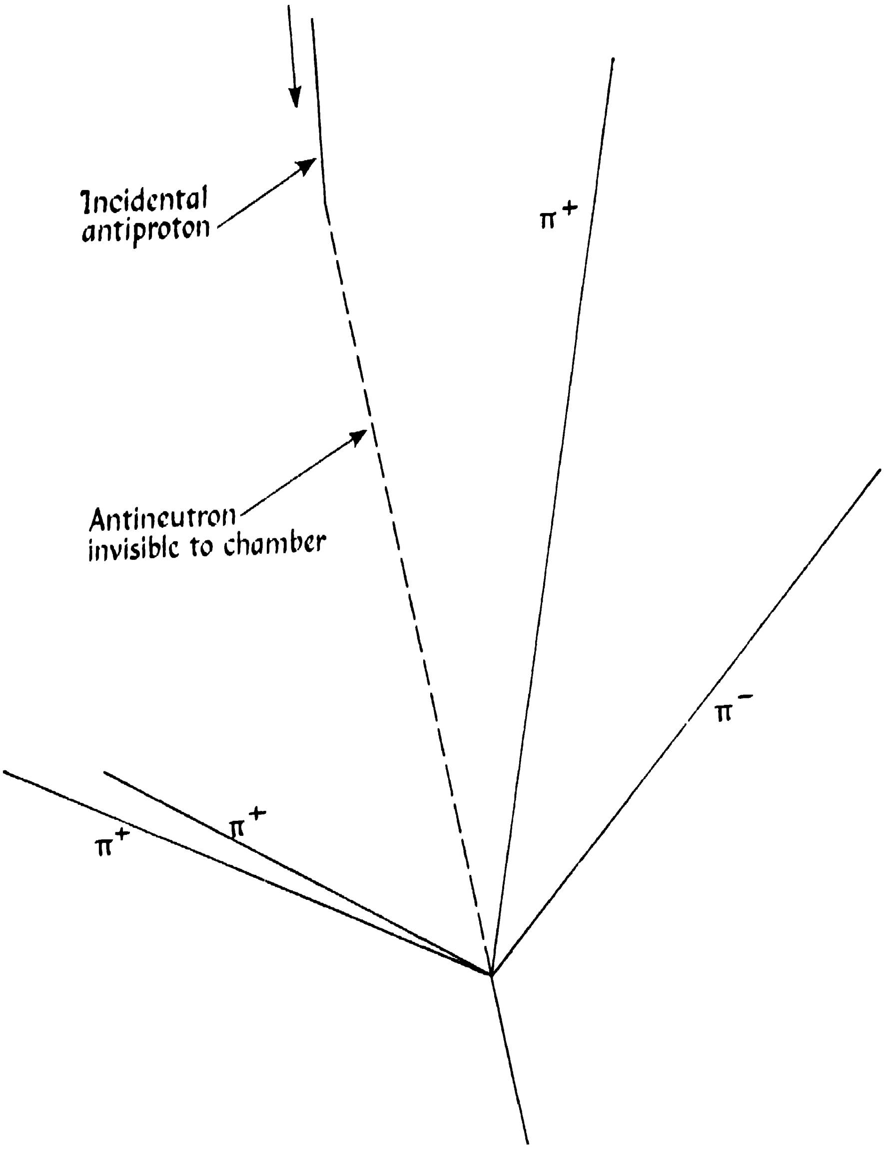


FIG. 1. The particle of interest is an antineutron. The antiproton enters from the top and proceeds for a short distance. Its path is seen to stop abruptly. At this point the antiproton collides with an ordinary proton producing a neutron and an antineutron both of which are invisible to the bubble chamber as they have no charge. However, the antineutron makes itself known by annihilating with another nucleon in the lower centre of the picture. The annihilation produces 5π mesons with an energy greater than 1,500 million electron volts. (See Plate 1a opposite.)

expressed the exact spirit of science: the quantitative principle. According to this principle science consists of measuring things and setting up precise relations between the measurements. Lord Rayleigh (1842–1919) expressed this in another famous passage by saying that our ideas become clear only as they become quantitative, so that only that which is measurable is susceptible to scientific, and indeed to exact, discussion and can truly be described as knowledge. On this view nature should ultimately be described by numbers—co-ordinates in space, times of events and coefficients which describe physical properties; and knowledge of nature advances by working out the relations between these numbers.[12]

The third underlying principle, which concerned the transitions of nature from one state to another, was the principle of continuity. It expressed the sense, deeply engrained in the outlook of the age, that the movements of nature are gradual. They may seem sudden and startling—a flash of lightning, an explosion, the eruption of a volcano. But the suddenness, said the scientific thought of the time, is only apparent.

To the nineteenth-century mind the processes of nature move imperceptibly from instant to instant. Between any two instants there is another, shorter instant; between any two positions there is an intermediate position. If any sequence seems abrupt or inexplicable it is only necessary to divide it into smaller sections. And the division could be carried on for ever; the processes of nature are infinitely fine and continuous.[13]

With these the nineteenth century pictured in nature and in science a fourth principle: the principle of impersonality. The scientist saw himself not as a person but as an instrument—passionless, unprejudiced and somehow more than human. Nature appeared as a great impersonal machine, going on its imperturbable way, which the human observer could only peek at. And the process of watching this wonderful engine was conceived as a passive one. The scientist did not invent, he saw. He did not use his imagination, but his observation. He did not create order among the natural phenomena; he humbly found it. Even viewing himself as an instrument, he did not recognize any interaction between that particular instrument and the phenomena under observation.[14]

In this way the nineteenth-century scientist cut himself off from the imaginative and the creative arts. Determinism, measurement, continuity and impersonality were parts of one vision: the vision of science as remote from the uncertainties and stresses of everyday life.

III. THE REVOLUTIONARY DISCOVERIES

Around the turn of the century the facts of scientific discovery compelled scientists to give up this vision of science and the outlook on nature which it embodied. A number of discoveries were made and a number of irregularities were confirmed which could no longer be squared with the principles which

underlay the accepted scientific theories. As scientists faced the implications of the new discoveries they developed a fundamentally new view of nature and of scientific activity.

1. *Physical sciences*

In the physical sciences, which had seemed so near to completion, there turned out to be range upon range of new facts and concepts beyond the edge which had appeared to place a limit to further progress. The view of nature since 1900 which physics revealed was richer and wider than the nineteenth century dreamt, and did more than the speculations of philosophers to change the outlook of the century.

(*a*) *The structure of the atom.* The fundamental unit of matter, the supposedly indivisible atom, was found to have structure and parts.

The discovery came from experiments in the passage of electric current through gases at low pressure which gives rise, roughly, to the phenomenon seen in neon lighting. In this phenomenon electricity streams from the cathode down the tube.

The unsolved problem of the time was whether the rays of electricity streaming down the tube are mere waves of electricity or are particles. In 1897 Joseph John Thomson (1856–1940) proved conclusively what others had already almost proved, that the cathode rays are particles, and he showed that they must be more than a thousand times lighter than the lightest atom. Moreover he showed that their behaviour was the same whatever gas he had in the tube and whatever metal he used for cathode.

Thomson had discovered the electron within the supposedly indivisible atom. Later, Thomson's pupils, led by Ernest Rutherford (1871–1937), found the structural relation of the parts to one another. They proved that the electrons spin in a cloud of orbits round the heavy kernel or nucleus of the atom. In particular, Niels Bohr (1885–   ) showed that the leap of an electron from one orbit into another always releases the same quantity of energy; and he thereby brought the new quantum physics into the understanding of atomic structure.

The nucleus still seemed indivisible, but Henri Becquerel (1852–1908) in 1896 had already shown that some atoms could change their chemical nature, spontaneously and without known cause. He and others after him, including Madame Marie Curie (1867–1934), discovered radioactivity, essentially the breaking up of a nucleus.

Later physicists who focused their attention on the nucleus finally established the possibility of fission in the atom. Until 1932 it was constantly supposed that if the nucleus had parts, the parts would be electric charges. In that year however James Chadwick (1891–   ) showed that the evidence pointed conclusively to the existence of some part of the nucleus which is electrically neutral; and there emerged the modern picture of the nucleus as

made up of two kinds of fundamental particles, positive protons and neutral neutrons, held together by an unexplained binding energy.

The discovery of the neutron provided a particle which could bombard the nucleus without being driven back by electrical repulsion. It thus became conceivable that the nucleus could be entered, made unstable and so caused to release its enormous binding energy. Such an action, if it released further neutrons, could be self-propagating. And so it turned out. In 1938 the German physicists Otto Hahn (1879–) and Fritz Strassmann (1902–) proved that such fission can take place in atomic variants or isotopes of uranium. The structure of the once indivisible atom could not only be described; it could be destroyed.

(*b*) *Relativity*. Space and time, which in the Newtonian system had been assumed to be absolute, were found to be relative. This revolutionary discovery was made in the effort to resolve discrepancies between observation and theory, particularly questions raised by the peculiar characteristics of light which became evident through efforts to determine the character of the aether, and by observations which showed a relation between mass and energy.

The new set of unit particles that entered into physics with the discovery of the electron gave some ground for thinking that all matter might be a configuration of electric charges. J. J. Thomson, who had long worked at the mathematics of this theory, had already shown in 1881 that a moving electric charge would appear to have mass. Now the fast-moving electrons were found to change their mass with their speed, and a relation between mass and energy began to seem probable.

But energy should surely be carried by a medium. The puzzle remained, how to detect this all-pervading medium, the aether. An experiment had been devised by Albert Abraham Michelson (1853–1931) and Edward Williams Morley (1838–1923) in 1887 which should have made it reveal its presence. Michelson and Morley argued that if the aether were a medium which carried waves of light as the air carries sound or the sea water waves, it should be possible to detect the passage of the earth through the aether and thereby throw light on the character of the aether itself. For example, if a ship is moving on a calm sea, the ripples it sends out seem, from the ship, to travel along the line of the ship's movement at a different speed from that at which they travel at right angles to the line of movement. These differences can be used to calculate the speed of the ship through the sea; and Michelson and Morley expected to calculate the speed of the earth through the aether by a refinement of this method.

Alas, light obstinately insisted on travelling at the same speed, in whatever direction it was sent into the aether and regardless of the motion of the source of light. That is, light covered a given distance across the earth's surface in the same time, regardless of how fast or in what direction the earthly object which was sending out the light was moving. The speed of light was found to be absolute; it did not behave as did other speeds such as sound or water waves,

which are affected by how the sender is moving through the medium—air or water—which carries them.

This sensational misbehaviour was a scandal to classical science for several years. Eminent physicists such as George Francis Fitzgerald (1851–1901) and eminent mathematicians such as Henri Poincaré (1854–1912) proposed various corrections including ones which would have the effect of cancelling out the speed of the earth through the aether. But though Poincaré went far toward a reformulation it was left to a young man of 26, Albert Einstein (1879–1955), to publish in 1905 a paper which put the matter into natural perspective.

Einstein looked for no minute error of formulation in the laws of physics, and for no ingenious device to correct them. Instead he followed a philosophical procedure first proposed by the Austrian physicist Ernst Mach (1838–1916). He set himself to look at the unwritten assumptions on which the laws themselves were built and asked whether it might not be there that the flaw in the physics of the nineteenth century was hidden.

The unwritten assumption which he challenged was that space and time are given to us absolutely. That this was no more than an assumption had been clear to Isaac Newton when he himself had made his great discoveries as a young man of 23, but the lesser scientists who followed him had rarely spared it a thought. They accepted space and time as boxes provided by nature ready-made, within which the events we observe take place.

But, asked Einstein, are space and time given to us ready-made? How does the physical observer carry out the process of measuring them? For example, how do two observers at a distance apart compare their times? They can do so, he noted, only by sending a signal from one to the other, and the signal itself takes time to travel through the space between them. The signal, in fact, is a ray of light or a similar electromagnetic wave or disturbance, and its speed cannot be taken out of the measurement. It follows that there is no abstract and impersonal way in which we can define 'now' for all observers everywhere at once. Every observer has only his own 'here and now'. In our experience of the physical world, space and time cannot be wholly separated from one another; each is part of a single reality. And the passage of light signals from one point of space to another is the essential link between the time at the two points.

With this analysis, which constitutes the Special Theory of Relativity, Einstein solved the paradox of the experiment by Michelson and Morley once and for all.[15] His view remained fundamental to physics from the time of the publication of his paper.

Moreover, once space and time were related, as Einstein related them, by light-signals, mass and energy were also related. Einstein showed in the same paper that his theory of relativity implied a fundamental equivalence between mass and energy. The relation between them could be expressed by an equation which involves the velocity of light as a fundamental constant; each

particle of matter represents an energy which can be measured by the product of its mass with the square of the velocity of light, $E = mc^2$. Mass and energy were thus seen to be two different ways of experiencing a single reality.

(*c*) *The quantum.* Energy, which the nineteenth century had assumed to be continuous and infinitely divisible, was discovered to consist of discrete units which could not be subdivided.

In the nineteenth century matter had been thought to consist of separate atoms but energy was thought to be passed from one piece of matter to another continuously. That is, it was assumed that we can transfer as small an amount of energy as we please from one piece of matter to another. Unlike matter energy was assumed to be capable of being divided and divided again into smaller and smaller quantities, without limit, for ever.

There were however some phenomena in the radiation of energy from a hot body which obstinately did not fit into this scheme. Mathematicians were puzzled but no one had thought of challenging the fundamental assumption. Then in 1899 the theoretical physicist Max Planck (1858–1947) did so—diffidently, but with startling consequences. He showed that the distribution of energy which goes into the different wavelengths when a hot body is radiating could be explained, and perfectly explained, but only on a different assumption.

We must, said Planck, assume that the energy is sent out piecemeal, in individual flashes, as it were unit by unit; that it does not ripple away from the radiating body continuously but goes out like a stream of bullets. The bullets, the pieces, are indeed very small but—and this is the crux of the explanation—their size for any one wavelength is fixed; they cannot be further subdivided. On any one wavelength, energy can be transferred only in units of one fixed quantity. Planck called this minimum quantity a quantum.

Max Planck was aware that his explanation broke radically with classical physics. Yet he remained loath to press forward to the full implications of what he had done. That was left to younger physicists, among whom one of the boldest was again Albert Einstein. These younger men did not hesitate to say what Planck's discovery implied.

It implied that energy has a structure, a certain graininess or coarseness, rather as matter has. Just as matter can be broken down into its fundamental particles but no further, so energy can be broken down into quanta but no further. The quanta play somewhat the same part in the movement of energy that the fundamental particles—protons, neutrons and electrons—play in the arrangement of matter.

If this is so, Einstein reasoned, then radiation of one wavelength—say, the yellow light of sodium—must be made up of quanta which are all equal. When sodium atoms glow these equal quanta are fired off individually, as if they were in a sense particles of light. This view of light as a stream of separate particles or photons was singled out as one of Einstein's major contributions to physics when he was awarded the Nobel prize in 1921.

But a basic puzzle still remained: if light can be pictured as made up of separate particles, how does it come also to behave as if it moved in a wave? An answer to this question was given by Max Born (1882–) in the 1920s. The waves of light are waves of probability—waves which describe only where we are more and where we are less likely to find an individual photon at any instant. And if we fix our attention on an individual photon, its position at any instant can be described only by a probability; it is not determined but probable.[16]

2. *Mathematics*

These changes in the outlook of physics went hand in hand with new interests in mathematics. In one way the connection was obvious: the new physics needed new kinds of mathematics. But in another way the connection was more subtle. It was as if mathematicians and physicists, often without knowing of one another's thoughts, came to be interested at the same time in the study of such subjects as discontinuity and probability. Pure mathematicians who were quite divorced from physics often seemed to have worked out a technique even before physicists needed it. By contrast, where mathematics was closely tied to physics, as in Britain, mathematicians often did not develop in advance the techniques necessary to express the revolutionary new ideas in physics.

(*a*) *The statistical approach.* Although the study of probability and of mathematical statistics had started in the Renaissance when problems of insurance and of gambling were first posed, it was only about the year 1900 that the central and critical concepts in statistical reasoning began to be laid bare. These rested jointly on the mathematics of reasoning about probabilities developed in the eighteenth century and on the theory of the distribution of errors of observation worked out by Carl Friedrich Gauss (1777–1855) at the beginning of the nineteenth century.

The essence of statistical reasoning, as developed by Andrei Andreevich Markov (1856–1922) and A. Liapunov (1857–1918) and others in Russia and by Karl Pearson (1857–1936) and, later, Ronald Aylmer Fisher (1890–) in Britain, was that it did not deal with clear-cut and self-evident issues, black versus white. It dealt with phenomena which may be described, and often may be explained, in a number of different ways, where therefore it is necessary to make a judgment and choose the description or explanation which seems to fit the evidence best. What mathematical statistics could do was not to take the place of such judgments, but to provide tools to help in restricting the area of judgment and in guiding the judgments by furnishing a quantitative basis, consistent from one occasion to another.

Statistical reasoning was unnecessary to describe and explain clear-cut phenomena such as the force of gravitation. It does not require statistical reasoning to demonstrate that a piece of matter will fall to the ground if it is dropped, nor to establish convincingly that the force of gravitation which is

postulated to explain this effect will also explain the movements of the moon and of the planets. The phenomena and the explanations are clear-cut, they can be formulated in precise equations, and as soon as this had been done by Isaac Newton the agreement between observation and explanation was seen to be self-evident.

In a less clear-cut issue, for example the effectiveness of a drug, the situation is very different. Every experiment designed to determine the drug's effectiveness is overlaid by unavoidable and substantial variations: patients are in many stages of a disease; their response is inevitably affected by many factors in their general health and physical condition.

Statistical techniques offer a way to extract positive results in a variable field such as this. In essence they ask how often the result which has been found might have been obtained by mere chance. By calculating this they make it possible to distinguish between observed results which might have occurred by chance and those which show a degree of consistency which would be unlikely to arise from chance and which may therefore be presumed to be related to the influence whose effect is being studied.

The statistical approach is essentially simple in conception. At bottom it divides observed phenomena into two parts, those which are random, attributable to chance, and those which are systematic, representing an effect. That is, the statistical approach recognizes that an effect can be isolated only to a certain degree of accuracy and that in order to determine whether an effect is real it is necessary to compare its area of uncertainty with the accuracy to which it can be measured. The effect must be judged relative to the error to which the estimate is liable. If the effect stands out plainly above the error, the result may be considered significant. But if the effect turns out not to be large when compared with the inherent errors of measurement, then it has not been established as significant. It may in fact exist but its area of uncertainty is too large to permit such a conclusion. The only hope then is to assemble more observations until they reduce the area of uncertainty to a point where the conclusion, though still not free from uncertainty, becomes useful.

(*b*) *New concepts of structure*. Mathematicians about the year 1900 came to take a new interest in problems of relation and of structure. The statistical approach embodied a less rigid and in some ways a more subtle and elaborate sense of the relation between events than was expressed in the nineteenth-century conviction that everything could be said by a few precise numbers. Mathematicians showed a growing interest in logical connections and in the general relations which could be pictured geometrically.

An important school of modern geometry was created in Italy, largely by the inspiration of Corrado Segre (1863–1924). Beginning from the neglected work of such German pioneers as Hermann Grassmann (1809–77), it explored the properties of non-Euclidean spaces and, later, the algebraic functions which can be constructed in them.[17, 18]

Other geometers took the liberation from the restrictions of Euclidean

space even further. Led by Henri Poincaré, among others, they began to investigate the most general movements by which one geometrical figure can be distorted to the shape of another—by which the closed surface of a cube can be stretched to fit the surface of a sphere, but cannot in any way be stretched to fit the surface of a ring. This subsequently became the subject of topology and proved one of the richest fields in modern mathematics.

At the same time the local and smaller-scale properties of non-Euclidean constructs were studied, under the inspiration of the work of Georg Friedrich Bernhard Riemann (1826–66).[19, 20] From this work there developed a wider form of the differential calculus which later turned out to be essential for the mathematics of relativity.

In this and other extensions of traditional mathematics there was evolved a new basic concept: the concept of the operation. It caused mathematics to be regarded not as a set of numbers held together by equations but as a set of structures turned into one another by operations. Attention shifted, for example, from the differential coefficient as a measure to the operation of differentiation as a process. The mathematician came to see himself actively, as a man who carries out new operations.

(*c*) *Logic and mathematics*. The basic assumption of mathematics, that the whole numbers are God-given and things in themselves, was subjected to the same kind of scrutiny as was the physicist's assumption that space and time are absolutes. Mathematicians at the turn of the century began to recognize that the whole numbers describe relations between things. As space and time describe physical relations, numbers describe logical relations; the number 2, for example, describes some logical relation common to all the pairs of things that can be imagined. They saw that numbers would have to be worked out and defined, from the ground up, as relations. Giuseppe Peano (1858–1932) and others set out about 1900 to formulate such logical definitions for numbers, and more generally for the operations of arithmetic. Alfred North Whitehead (1861–1947) and Bertrand Russell (1872–) went further and tried from these beginnings to establish all mathematics as a formal expression of logical relations.

In the course of this work Whitehead and Russell uncovered some unexpected assumptions in the very foundations of mathematics. At the same time they showed that the symbolic expression of thought, either in language or in other symbols, requires much subtler analysis than had been given it hitherto. Much of the philosophical analysis of the twentieth century, and particularly the philosophical movement begun by Russell's pupil Ludwig Wittgenstein (1889–1951), was set in motion by these discoveries in the semantics of all symbolic forms of expression.

Among the difficulties which Whitehead and Russell did not resolve, however, was the searching question posed by the mathematician David Hilbert (1862–1943): is it really self-evident, is it even true, that when a system of axioms such as that of Euclid has been set up, every true proposition

can be proved from the axioms and every false proposition can be disproved? Is it not possible that there are propositions which can neither be proved nor disproved in a finite number of steps?

In 1931 Kurt Gödel (1906–) showed that it is indeed possible. Any logical body of mathematical thought which has an axiomatic basis rich enough, in a technical sense, to permit the formulation of significant statements and questions also turns out to be rich enough to permit the asking of questions which are unanswerable within the system. These questions are unanswerable, not for the practical reason that they are too difficult; they are theoretically unanswerable.

This finding opened a chasm in the very foundation of mathematics—the assumption that all the propositions in a system of mathematics either follow from or contradict its axioms. It dealt the notion of truth and falsehood a severe shock, for truth can no longer be based on mere formal consistency if there are propositions which, within a given system, are neither true nor false in any effective sense. It undermined the method of developing science from a set of axioms but offered no alternative method. The full effects of this discovery would only appear as they spread outward from arithmetic and mathematics to the empirical sciences.

3. *Biology*

Advances in the biological sciences about the turn of the century seemed less radical than those in physics. Their consequences however were as far-reaching, and in the long run precipitated a change in outlook which was equally profound.

(*a*) *Genetics*. The problem which had been raised by evolution was the discovery of a mechanism of inheritance which could preserve variations between individuals, especially those which conferred a biological advantage on those members of a species in whom they had happened to occur. The great opening attack on this problem had in fact already been made by an Austrian monk, Gregor Mendel (1822–84), who before the end of the nineteenth century had carried out a thoughtful series of experiments in the breeding of plants, chiefly peas. The significance of these experiments was not appreciated even by those who knew of them. Certainly they were at variance with the deepest preconceptions of his contemporaries.

About the year 1900 Mendel's papers attracted the attention simultaneously of a number of biologists who were interested in heredity. Several of these biologists perceived that Mendel's work gave a radically new view of inheritance and laid the groundwork for the new study which would make it possible to understand how evolution had been able to fix advantageous strains and to form new species.

The mechanism of inheritance which Mendel conceived was very simple—and there is evidence that he had conceived it on theoretical grounds even before he put it to the test of experiment. In Mendel's view such a trait as, for

example, the colour of the peas which he studied in his monastery garden is fixed by a pair of factors, later called genes, one inherited from each parent. If both genes in the pair are the same, of the type which causes the pea to be green or that which causes it to be yellow, then the pea will indeed be green or yellow. But if one gene is of one type and one of another, then the colour of the pea is determined by whichever type is dominant, in this case the gene for green colour, and not by the type which is recessive, in this case the gene for yellow colour.

The biological difference between a green pea which has both genes of the same kind and a green pea which has a dominant green and a recessive yellow gene, Mendel pointed out, lies in the ability of the second pea to hand on the recessive gene to the next generation. Since only one of the pair of genes is contained in the reproductive cell, the pea will hand on the gene for green to half its descendants and yellow to the other half. If the pea is crossed with a green pea which also happens to possess genes of both kinds, a quarter of the descendants will, by chance, receive yellow genes from both parents and these peas will be yellow although both parents are green.

Here, then, is a mechanism which does not average the variations of individuals. Once a genetic difference has been established in an individual, this mechanism will preserve it. The difference might spring only from a recessive gene, and this might remain submerged in the population for many generations. But it would continue to be handed on from generation to generation, and now and again it would reappear in the mating of individuals both of whom happened to carry the same recessive gene.

One question had still to be answered in order to elucidate the working of evolution: are all genes already present in a population or can new genes appear in it? And can genes alter or be altered? A preliminary answer to this question was made about 1900 by Hugo de Vries (1848–1935), who demonstrated that certain plant deviants or sports bred true. His studies indicated that the hereditary constitution does change from time to time, and he named the spontaneous change mutation, although subsequent investigations found that the phenomena which he had observed did not constitute true genetic mutations. Later, other workers demonstrated and analysed other types of mutation which provided specific gene change. Thus not only are the determinants of heredity that are already present constantly being shuffled, but also new forms of determinants are continually appearing. The ever-varying combinations of old and new determinants generally affect the reproductive success of their bearers. They are, then, the material on which natural selection operates, with directive evolution and adaptation as a result.[21]

(*b*) *The nature of living matter.* The origin and character of life has always interested some biologists. Study of chemical characteristics and reactions in the organism focused the pursuit of this question on the chemical and other features which affect the growth and behaviour of cells, and launched the new twentieth-century science of biochemistry.

The discovery of the mechanism of inheritance in the genes was consolidated by the study of the structure and division of plant and animal cells. It was shown that cells contain microscopic structures which are string-like and which, because they can be stained, were called chromosomes. These chromosomes lie in pairs in the cell, and divide when the cell divides. The position of the genes was located by breeding experiments and statistical methods; in addition, microscopic study showed dark spots in some chromosomes presumed to coincide with the presence of genes, though they were never regarded as genes made visible.

The chromosomes and the genes on them appeared to be complex chemicals. It was found that they can be altered by strong chemical or physical action—by irradiation with X-rays, for example, or treatment with mustard-gas. If chromosomes in the reproductive cells have been altered in this way, then the offspring will show differences which can be inherited from one generation to another.[22] Thus microscopic chemical structures in the sperms and ova were seen profoundly to affect the living creature which grows from them, not merely for one generation but for many. In addition, from other points of view, much study was given to those points of a fertile ovum from which the specific organs of the full-grown animal take their beginnings, and to the chemical stimuli which can direct and change their growth.

New speculation on the possible transition from dead matter to living being was stimulated in the 1920s by the study of viruses.[23] Some plant diseases, for example of the tobacco plant, were found to be induced not by bacteria but by simpler structures. These structures can be isolated from the plant and in that state can be crystallized as chemicals. The crystals are in themselves quite inactive when isolated; yet when they are brought into contact with a healthy tobacco plant the plant becomes diseased. When an infective agent of this kind, called a virus, was first identified it seemed to some to stand on the threshold between dead and living matter, with a foot in each.

But the viruses turned out to be more complicated than was first thought. It became fairly clear that they are not independent agents, and that they are multiplied as a result of the altered metabolism of the host plant. In the presence of its host, the tobacco plant, the dead chemical becomes active; it deflects the host's metabolism in such a way that more virus is produced, and a disease results which spreads over the leaves of the plant.

Nevertheless there was evidence that the activity of the viruses does reside in their chemical structure. Moreover the chemical structure of the viruses was found to bear a likeness to that postulated for the genes which influence the development of living cells. Many biochemists hoped to find in the chemistry of the viruses a bridge across which dead matter steps to life.

If a living thing is defined as one that is capable of reproducing itself in the same form, the problem is to find a mechanism which shall give a chemical arrangement of atoms this property of copying itself.

Toward the middle of the twentieth century a possible mechanism was

identified by which a chemical could copy itself and ensure that the copy would match the original. It was shown that some of the important constituents of living cells are chemicals, nucleoproteins, whose atoms are arranged in a special form. F. H. C. Crick (1916–) and J. D. Watson (1928–) showed that a fundamental unit in these, deoxyribose nucleic acid (DNA) has a molecule which consists of two spirals each made up of a string of atoms. These two strings of atoms match one another and are joined by cross-links in such a way that the two spirals wind in and out of one another.

Many chemists believed that this is a form peculiarly adapted to copying itself. If one spiral should break away from the other, new atoms could join on to each spiral only at the places where they were found on the other spiral. In this way each spiral could induce the formation of another spiral of the same kind, linked to it at the right places. This chemical structure was recognized as holding a possible key to the problem of life.

It was of additional interest because it was seen to play a role in the heredity of widely diverse organisms. A number of other chemical substances proved also to be indispensable in the vital processes of very different organisms; vitamins for instance were shown to be as important in the metabolism of bacteria as in that of man. The chemical bonds of one particular molecule, adenosine triphosphate (ATP), were discovered to be responsible for the transfer and utilization of energy in all life processes. A particular class of compounds known as enzymes, primarily protein in constitution, were shown to be the prime regulators in many biological processes.

Thus features of organisms became apparent which substantiated at a biological level the hypothesis that all organisms are related to one another. But the biochemists of the first half of the twentieth century did not confine themselves to the mere confirmation of the evolution hypothesis. They went far towards explaining many varied and important vital phenomena in molecular terms, and thus made great strides in bringing to biology the same standards of accuracy and objectivity which had characterized the more exact physical sciences for a long time. In doing this they gave further ground for the growing conviction that all living processes, those of the mind as well as those of the body, can be traced back to material causes.[24, 25]

4. *Social sciences*

In the long run the visible and explicit changes in the conditions of life brought by the physical sciences might not prove to be the most important. For the twentieth century began to explore the minds and social behaviour of people. The practical effects of these pioneer studies did not leap to the eye. Yet they might lead to an understanding of man which in time would change the foundations of civilization.

(*a*) *Learning and conditioning.* The manner in which learning takes place had long been the subject of speculation and of educational theory. In the

eighteenth century the philosopher David Hartley (1705–57) had singled out association as an important process in human thought.

About the year 1900 the Russian scientist Ivan Pavlov (1849–1936) began a long study of association in animals. He developed a technique for associating one stimulus with another and measuring the response when either of the stimuli was present. For example he associated the stimulus of ringing a bell with the stimulus provided by presenting the experimental animal with food. The response to the food could be measured by the amount of saliva produced. After a number of repetitions the animal came to associate the ringing of the bell with food and to produce saliva when the bell was rung, even if no food was presented. The action by which an animal salivates at the sight of food is automatic, a natural reflex. Pavlov called the action by which it comes to salivate at the sound of the customary bell a conditioned reflex.

He made a detailed study of conditioned reflexes: how they are formed, how they can then be inhibited and even destroyed, how they can once again be revived. On this study he based an interpretation of all animal and human habits, which he conceived as an elaborately linked array of conditioned reflexes. His work was of great importance in showing empirically that association enters deeply into behaviour.

Later studies covering areas which Pavlov did not explore found that the process of learning, in animals and in man, is more varied and more subtle than he supposed. Studies of animal behaviour by Konrad Lorenz (1903–), N. Tinbergen (1907–) and others brought out the role of instincts in the learning process and the variety and richness of symbolic stimuli to which animals respond, and offered new insights from observation of animals in their native environments where they were not limited by controlled laboratory conditions. The importance of exploratory behaviour of children and animals as a first condition of learning was also established. Whereas Pavlov's work tended to foster a purely behaviourist approach to individual psychology, other approaches made it clear that human responses are not developed in isolation one from the other, but in terms of a structure of relationships or *Gestalt*, built up in the mind.

(*b*) *Motivation.* No less far-reaching in implications for human behaviour were Sigmund Freud's (1856–1939) explorations into the drives and desires that lie below the surface of man's consciousness. As this Austrian physician studied his neurotic patients and sought ways to relieve their mental anguish, he traced many of their neuroses to suppressed desires which generally outraged the taboos of society and which grew out of experiences in early childhood. He assumed that normal people also possess these same desires but are able to repress them successfully or to canalize them into socially acceptable forms of behaviour.

On the basis of these observations Freud developed a theory as to the innate drives with which each individual is born, especially the impulse to love and to be loved, and of the manner in which these drives work themselves out

during his growth and development. He formulated the concept of the unconscious as the repository of the desires which the individual suppresses as he acquires his sense of himself and his ability to conform to the norms of his society. Neurotic persons, he concluded, are those who have been unable to handle the process of repression successfully and whose unconscious is loaded with unmanageable desires which rise threateningly to the surface, or, often in disguised form, produce unacceptable behaviour. He developed the method of psychoanalysis as a tool of research and a means of treatment, to explore the nature of the suppressed experiences and desires and, in treatment, to bring them to the patient's consciousness in order that he might be helped to deal with them.

Freud's pioneer speculations had a profound effect on thinking men and women. His observations and theory destroyed both the eighteenth-century picture of man as a rational being with rationally motivated behaviour, and the mechanistic concept of the human organism as simply a series of responses to external stimuli. Other psychologists who followed gave prominence to other human drives in addition to those which Freud stressed. His analysis made only a start toward unravelling the complex processes in the life of the mind, conscious and unconscious, and in the formation of human personality. But Freud made men aware, inescapably, how much irrational forces and hidden motives lie behind human behaviour.[26]

(*c*) *Culture and race.* The new insights into man's individual motivation and behaviour were paralleled by new perspectives on his social forms which undermined the assumption that western civilization was a culminating stage in social evolution.

Interest in folklore and in the customs and arts of primitive peoples during the nineteenth century had resulted in numerous publications, such as the collections of folk tales by the brothers Jakob Ludwig Karl Grimm (1785–1863) and Wilhelm Karl Grimm (1786–1859), and in the establishment of ethnological museums. The classical scholar James G. Frazer (1854–1941), attempting to trace to its beginnings the classical story of the Golden Bough, had explored the legends of many nations and the rituals of many religions and had found evidences of similar practices such as symbolic magic and fertility rites among peoples widely distant in time and place. The publication of his accumulated materials in *The Golden Bough* (1890) had prompted the question: were these likenesses produced spontaneously, by a common mental process which all men share, or did they point to a single or a few centres of origin of human culture from which such practices had spread over the world?

Answers to these and related questions were sought in detailed studies of the surviving cultures of primitive peoples. Franz Boas (1858–1942) and his students studying the cultures of North American Indians and Bronislaw Malinowski (1884–1942), A. R. Radcliffe-Brown (1881–1955) and their associates studying island cultures in the Pacific and tribal cultures in Africa found great differences among peoples and yet likenesses also, in that all

cultures, in one way or another, reflected common human needs. They found little evidence of the successive stages from lower to higher societies which the social evolutionists had projected, for social forms appeared in a great variety of combinations. Moreover some similarities, such as those which Frazer had noted, proved to have quite different meanings when seen in the context of a total culture. These studies made it apparent that all the social institutions, value systems and patterns of behaviour in any society are interrelated and that the culture must be seen as a whole if one would understand its parts and the people who are shaped by it and who pass it on to their children.

Franz Boas also cut the ground from under the assumptions of racial superiority by his study of the *Mind of Primitive Man* (1901) in which he found that the mental processes and capacities of the primitive Indians whom he studied were comparable to those of civilized men, differing only in the cultural experience and norms to which the processes were applied. His observations were reinforced by the persistent failure of efforts to link mental capacity with physical characteristics.

The anthropologists' findings on culture and race were not fully accepted until political events changed the balance of world power and forced those who had assumed that they belonged to a superior culture and race to reassess themselves and their cultures. They did however provide a basis for such a reassessment and the beginnings of a new understanding of man in society.[27, 28]

IV. THE CONCEPTS BEHIND THE DISCOVERIES[29, 30]

Even more profound than the body of new facts uncovered in the sciences from the opening of the twentieth century was the movement in the underlying assumptions of science. This subterranean movement in outlook—in the way scientists thought about nature and laymen in time came to think—was the real scientific revolution of the twentieth century. It grew out of the process of coming to terms with the new facts and it provided the new approach which carried scientific progress forward at an accelerated rate.

1. *Structure*

A noteworthy feature of twentieth-century science was that much of it lacked the rigid numerical character which was thought essential to science in the nineteenth century. Preoccupation with number and measurement was overshadowed by a growing interest in structure.

In the social sciences concepts which offered powerful ways of organizing knowledge to make it more orderly and penetrating, such as those created by Freud and Pavlov, came to be recognized as in every sense scientific, though they were seldom amenable to measurement or even to comparison. In the biological and the physical sciences, also, science was seen less and less as an accumulation of numerical measurements and more and more as a complex

of logical and empirical relations. It was the relations, the connections between phenomena, the structure of the network of connections, which interested the scientist.

The bacteriologist would not give a numerical answer to the question of how a sulpha drug prevents the multiplication of bacteria. His explanation would be in terms of the geometrical structure of the drug: the atoms in the drug are arranged on the same pattern as the atoms in one of the foods which the bacteria need; thus the bacteria accept the drug, as it were by mistake, deceived by the shape in which its atoms are arranged.

So the cosmologist became less interested in the age of the universe than in the logic by which an age could be ascribed to it; and he was less interested in the size of the universe than in whether its size implies that it is open or closed. The nuclear physicist was fascinated by the strange relations between the numbers of different particles in a stable nucleus, not because the numbers were interesting in themselves but because they might provide a clue to the structural arrangements of particles which make a nucleus stable.

The quantitative principle was not thrown overboard, for science cannot exist without precise data. But it ceased to dominate the minds of scientists as it had in the nineteenth century. The twentieth-century scientist saw the accumulation of measurements no longer as an end but as a means. He needed exact numbers not for their own sake but as a step towards framing what he was really looking for, the laws which express the structural relations in nature. The quantitative principle became subservient to something more profound—the concept of structure.

2. *Discontinuity*

The nineteenth century assumed continuity in nature; yet discontinuity had already been established in the atomic division of matter. Physicists, however, did not then appreciate its significance.

Discontinuity as a principle was brought into the open when energy also was shown to have an atom-like structure and to travel on any one wavelength in quanta of a definite size. Once it had been demonstrated that energy cannot be divided indefinitely and cannot be transferred continuously, the nineteenth-century principle of continuity disappeared from physics. The underlying structure of the world was accepted as discontinuous. And with the recognition that both matter and energy exist and act only in discontinuous units of definite sizes, the possibility of an exact description of the universe was seen to be an illusion.

The need to turn to statistical methods had long been accepted in fields such as biology where the environment in which an experiment is conducted clearly contributes a background of unavoidable variations—differences between one experimental animal and another or in temperature and other conditions from one day to the next. Conclusions have to be drawn from such experiments which represent not finality but the preponderant weight of evidence. There

always remains a possibility that the conclusions will be modified, and any numerical results in them are necessarily surrounded by some area of uncertainty. In the traditional view the reason for the appeal to probabilities in these areas was only the lack of complete knowledge; if perfect knowledge of the small fluctuations in background could be secured, even a biological experiment might in theory be perfectly precise and conclusive.

But the new discoveries in physics made it clear that it was really senseless to talk, even in principle, of having complete and exact knowledge. For knowledge is limited by the extent to which it can be supposed that things remain fixed, even in principle. And when for example scientists attempted to fix precisely the quantity of light reflected, say, from the page of a book, they found that the pointer on the light meter trembled; the quantity of light cannot be held steady any more than can the atoms which make up the pointer.

The fact that the pointer would tremble was already known in the nineteenth century. It had been discovered by the botanist Robert Brown (1775–1858) when he observed under the microscope the trembling of vegetable spores on the surface of a liquid. But the full implication of the Brownian movement was not grasped until the twentieth century.

The implication which came to be recognized is that in a universe in which matter and energy are atomic there is a limit to the accuracy of every description. Every description, however short the time which it covers, is an average taken over that time; because matter and energy make discontinuous jumps we cannot, even in principle, reduce the interval of time of any description of them to nothing. The pointer will tremble on any instrument that can be devised, however delicate, however carefully controlled and however shielded from all outside fluctuations. For in a universe in which matter and energy are both atomic, they themselves provide a background of sudden and discontinuous fluctuations which cannot be excluded.

In a continuous universe one could regard the statistical variability of results simply as errors of measurement which would disappear if one took more and more accurate readings at shorter and shorter intervals of time. But in a universe in which matter and energy are both discontinuous the difference between one measurement and another is no longer only an error of the observer. Nature herself is supplying a statistical distribution of events from one moment to the next, in discontinuous jumps.

3. *Uncertainty and chance*

The principle of uncertainty which the twentieth-century scientist came to accept, however, went far beyond the impossibility of making the measuring instrument precise. It went to the nature of matter and energy which the scientist sought to observe. Uncertainty in describing the course of the electron was implied in the very character of the electron itself.

From 1900 the ideas of quantum physics could not be made to match with the classical mechanics of particles. Fantastic properties had to be given to an

electron whenever it sent out or took up a quantum of energy. The difficulties grew until in the 1920s it began to be seen that it was simply impossible to make a theory to describe these minute happenings and still hope to keep it rigidly laid out in the classical pattern of causes and effects.

The difficulty was apparent, for example, in the behaviour of electrons when an atom radiates one of its characteristic colours, such as a yellow line of sodium. It gets the energy for this when one of its electrons makes the leap from one of its characteristic orbits to another. This leap takes no time and does not pass through the space between; the electron disappears from one orbit and instantly appears in another. It did not seem to make much sense to call something with this behaviour a particle or even to ask whether what appears in the two orbits is the same electron. Neither did it make sense to give the electron one place at one time in its orbit; its possible positions are spread round the orbit like a wave. The electron, in short, was seen to behave as an electron and nothing else, with its own unusual but definite laws; and words like particle and wave were mere metaphors, each of which describes an aspect, and no more, of the whole algebra of its behaviour.

When for example light from a sodium lamp was beamed through two holes in a screen, the light was found to ripple from the two holes in waves which overlap to form a pattern of dark and bright bands. These waves are made up of single photons of light sent out by the leaps of single electrons. But through which hole any one photon goes, to take its place in the pattern of dark and bright, no one can tell. The single photon, the piece of energy, is set off on its journey and it appears at the end in one of several possible places. This is all that can be said of it; it is useless to ask more.

Useless, that is, so long as one insists on following single photons one by one. For one finds that the units of energy, as of matter, obstinately contradict the dogma of classical mechanics which declares that the processes of nature must be infinitely predictable. What one finds to be predictable is the statistics of collection—that half the light goes through each hole, and makes a pattern of dark and bright bands.

The conviction that there is no way of describing the present and the future of these tiny particles and events so that they appear completely determined was put into a formal principle in 1927 by Werner Heisenberg (1901–) and given the name of the 'principle of uncertainty'.

Heisenberg showed that every description of nature contains some essential and irremovable uncertainty. For example he found that the more accurately he attempted to measure the position of an electron the less certain he could be of its speed. The more accurately he tried to estimate its speed the more uncertain he was of its precise position. The future of the particle can never be predicted with complete certainty because it is impossible to be completely certain of its present. The future of these small-scale events can only be predicted with some range of alternatives, some uncertainty. And once any uncertainty in prediction is recognized, in however small and distant a corner

of the world, then the future is essentially uncertain—although it may remain overwhelmingly probable.

The principle of uncertainty refers to very small particles and events. But these small events are not by any means unimportant. They are just the sorts of events which go on in the nerves and the brain, in the giant arrangements of atoms in the chromosomes, or in the behaviour of matter under extremes of heat or cold.

The discovery of the principle of uncertainty had a profound effect. At first it brought a severe shock to scientists accustomed to think, in nineteenth-century terms, that a law of nature is a rigid conjunction in which a known cause is described and a definite effect predicted from it. For it meant that nature could not be described as a rigid mechanism of causes and effects. What had seemed to be a clear relation of cause and effect was only a statistical accumulation, in which the uncertainties of the minute individual events averaged themselves out. Yet the successes of science in the nineteenth century had been won by fitting nature with a causal mechanism.

Scientists were accustomed to think that if a law of nature has been rightly determined a given procedure will always be followed by the same result. They were not accustomed to the idea that it will sometimes be followed by one result and sometimes by another or that one result is more probable than another. They did not expect to find the word 'probable' in a law of nature. To the nineteenth century the word 'probable' was a confession of ignorance—ignorance which could, in principle, be removed. But the twentieth-century scientists could not hope to remove the word 'probable' from the laws which govern very small events. They knew that the tiny events which take place within atoms cannot be described by laws which contain any stronger word than 'probable'; that in this sense chance is inherent in nature.

By the second quarter of the twentieth century the principle of uncertainty was no longer a strange or unsettling idea. To the later generation of physicists it seemed altogether natural and sensible. It did not seem to them to have taken the order out of science. Rather it had the effect of taking out the metaphysics and focusing upon the purpose of science: to describe the world in an orderly scheme or language which will make it possible to look ahead. It left no place for such general beliefs as Laplace's assertion that if we knew the present completely we could completely determine the future. According to the principle of uncertainty there simply is no sense in asserting what would happen if we knew the present completely; we do not, and plainly we never can. The principle allows no assertions at all about whether we could or could not predict the future of an electron, supposing that we knew this or that about its present. It merely points out that we cannot completely know its present.

To the scientists who grew up in the twentieth century the principle of uncertainty stated in special terms their fundamental view of science—that science is a way of describing reality; it is therefore limited by the limits of observation and it asserts nothing which may not in principle be tested by

observation; anything else is scholastics, not science. The nineteenth century was dominated by Laplace's belief that everything can be described by its causes. To the scientist of the twentieth century this was no less scholastic than the mediaeval belief that everything is contained in the First Cause.

4. *Operation*

The twentieth century also evolved a radically new view of the relation between the scientist and what he observes. Man came to be seen not as a detached observer but as an irremovable part of his observations.

The nineteenth century was inspired by a belief in the impersonality of science and of all knowledge. It assumed that all its concepts, such as space and time, exist absolutely and outside of the observer. It assumed a sharp division between the observer and the natural world which he observes. Nature was regarded as a chain or network of events which unroll themselves in imperturbable sequence, and of which the observer is a witness but not a link.

When Albert Einstein examined the hidden assumptions in the physics of his boyhood he saw that this view of the relation between nature and those who observe it is simply unrealistic. He did not ask whether such a view was tenable in some abstract sense but whether it was practical. Does science in fact record impersonal events? Can it separate the fact from the finding, and distil the event from the observation of it?

Once Einstein had asked these questions the answer was plain; and the answer was 'No'. He saw that physics as the scientist actually practises it does not consist of events; it consists of observations. And between the event and those who observe it there must pass a signal, a ray of light perhaps, a wave or an impulse, which simply cannot be taken out of the observation. Event, signal, and observation: this is the relationship which Einstein recognized as the fundamental unit in physics. Relativity is the understanding of the world not as events but as relationships.

This was the fundamental change which relativity induced in all scientific thought. It brought the observer into the observation and, through it, into the formulation of the law. This of course did not mean that the law of nature was at the mercy of the individual observer. On the contrary, relativity and its extensions usually stipulate that a given law of nature must be so stated that it is equally applicable to all observers.

Thus science in the twentieth century was no longer a great heap of facts, each complete, self-contained and impersonal. It was a way of giving order which included the process by which facts were obtained. Facts were not given to the scientist by nature; he had to get them himself. Science thus became an activity, a sequence of operations that had to be carried out by people.

What the scientist found could not be divorced from his operations. The

length of a stick cannot be divorced from the operation of measuring it, or the time on two clocks from the operation of comparing them.

In the same way it is possible to regard the principle of uncertainty as stating a limitation imposed by the presence of an observer. That is, one can consider that the behaviour of an electron is disturbed by the act of observing it and this is the reason why it cannot be described precisely. If for example an observer wanted to see the electron, he would have to shine a light on it, and this light would give some of its energy to the electron and so would change its course. Thus the act of observation would itself change the conditions which he was trying to describe; and in so small a unit as an electron the change would be important.

Twentieth-century science was able to gain new insights into reality only because it recognized the status of the observer, of the scientist in his work. It learned to understand the structure of the world more deeply because the scientist no longer tried to isolate the facts of nature from the operations by which he sought to find them.[31, 32]

V. THE UNIFYING OUTLOOK

Thus the underlying assumptions on which the nineteenth century formed its picture were replaced. In place of the quantitative principle, the scientist of the twentieth century thought of himself as pursuing a concept of structure. In place of the principle of continuity, the scientist recognized that the underlying structure of the small-scale world is discontinuous. In place of the principle of determinism or cause and effect, he recognized that the smallest units of matter and energy follow laws which can only be described by probabilities and whose predictions are therefore always surrounded by an area of uncertainty. In place of the impersonality of science came an understanding that the operations of the scientist enter inextricably into his findings. These were revolutionary changes in the outlook of science, and they make it appropriate to speak of a second scientific revolution.

The total effect of the new outlook was to overthrow the stark and mechanical image of the scientist serving an inhuman truth, remote from the everyday world, which the nineteenth century set up. Its place was taken by a richer image in which the scientist saw himself as carrying out an essentially human and personal activity, from which he must create an order, an understanding of the world by the projection of his own mind.

This was the most subtle change which took place in the view of science and of all knowledge. The twentieth century broke with the view that knowledge is passive, that it accumulates the facts that nature provides like a card index, and that the scientist need do nothing more than keep the index accurate and tidy. Instead it saw knowledge as a constant activity.

It ceased to ask that a law of nature be formulated as if there were no observers; it asked only that it be formulated in such a way that it looks the

same to all similarly placed observers. When it asked that a law should be universal, it did not ask for a formulation which would hold in the absence of human observers. It asked, rather, for a formulation which should be valid for them all, however different their circumstances. This was the new meaning of universality.

At the same time it gave to the seeker after knowledge a creative role which science in the past had denied. A fully deterministic universe, as Laplace pictured it, carried the implication that everything that men do is already determined. On this nineteenth-century view man invents nothing and adds nothing to the world. Everything is wholly conditioned by past events.

This interpretation of nature as a machine ticking inexorably on a wholly determined course was no longer implied by the facts of twentieth-century physics. For the facts of physics left no room for any theory which does not include an unpredictable chance element in every forecast. The facts of modern physics say, for example, that one half of the atoms in a piece of plutonium will undergo radioactive disintegration in 25,000 years, but they do not say which half. Nor do they say of any specified atom in a piece of plutonium whether it will or will not disintegrate in the next 25,000 years, or in any other period of time.

To the scientists of the mid-twentieth century there appeared no possibility that there could be hidden somewhere a theory which would allow them to make exact forecasts of this kind about the small-scale events in the atom. In fact the mathematician, John von Neumann (1903–57), showed that any deterministic law which exactly predicted the occurrence of such phenomena would contradict some of the known and established facts of physics.[33, 34]

The concept of chance, as it entered into modern physics, did not mark any relaxation of scientific rigour. It was as clear and well defined as was the principle of strict cause and effect in the past. The area of uncertainty with which it was necessary to surround predictions was as well formulated and as intellectually lucid as was once the point of certainty. These were the tools of the new science, more supple and less familiar than those of the past, and highly practical, but no less scientific for that.

VI. THE SCIENTIFIC IMAGINATION IN ACTION

As science and all knowledge came to be regarded as personal activities, the scientist was placed in a new relation to his theories. Isaac Newton did not think of himself as inventing the law of gravitation, and Charles Darwin did not think of himself as creating the theory of evolution. They thought of themselves as uncovering what had always been there. Each pictured the law which he discovered as wholly objective, something which existed in itself, as positively as a stone or a clockwork.

The modern scientist saw this as too simple and too impersonal a view of knowledge. He presumed that the laws of nature did have an existence in

themselves but that their character was more delicate, more elaborate and immensely more varied than anything that men were able to trace. Therefore the order that the scientist could find in nature was surely only one of many orders which might be found. And the particular order found by the scientist was thus in part created and imposed by his own imagination.

Let us consider a concrete case. Isaac Newton thought that each piece of matter was attracted to every other piece by a force of gravitation. The forecasts which he based on this law were almost entirely successful until the end of the nineteenth century. But they were not entirely successful. They failed, for example, to predict a small but obstinate discrepancy in the orbit of the planet Mercury.

In 1916 Albert Einstein published the General Theory of Relativity. This included all the predictions Newton had made and in addition it correctly accounted for the irregularities in the orbit of Mercury. It also forecast a remarkable phenomenon, the bending of the path of light towards massive objects. This was confirmed by observations on the total eclipse of the sun in 1919.

The General Theory of Relativity in its turn opened up a new series of problems. Einstein came to formulate it in such a way that it implied a closed universe. But it was then shown, mathematically, that the size of a closed universe cannot be stable; it must either expand or contract. And indeed, in 1924, Edwin P. Hubble (1889–1953) observed that the light from distant galaxies is increased in its wavelength in a way which is naturally explained by assuming that all the galaxies are moving away from one another. A whole new field of cosmology was thus opened up.

Einstein's General Theory of Relativity was not simply an enlargement of Newton's laws which adjusted them to cover a wider range of phenomena. It was a wholly new way of looking at the phenomena. It threw overboard the idea of a force of gravitation, and indeed the whole concept of force. In its place it regarded the interaction of massive bodies—and of light—purely as a geometrical effect, caused by geometrical irregularities in a four-dimensional space–time.

There was thus no intellectual link at all between the mechanism which Newton conceived to be driving the planets and the new mechanism which Einstein conceived.[35] Yet the predictions which both gave, for example for the orbit of the earth, were nearly always indistinguishable.

The laws of nature, as the twentieth century saw them, might thus be conceived in forms which philosophically are widely different and which may yet give almost the same predictions. The choice which a theoretical scientist may make among possible forms of law is therefore by no means inevitable. The particular order which he finds in nature is in some ways a projection of his mind.

In this century many new connections were found between the different phenomena of nature. Albert Einstein, who was always striving for new

unifying ideas, showed how to connect time with space, mass with energy, and gravitation with the structure of space. To the end of his life he was still working on a unified field theory, which was intended to find a link also between gravitation and electricity.

J. J. Thomson, Ernest Rutherford and Niels Bohr elaborated a model of the atom which drew together a mass of diverse phenomena, all the way from electricity to chemistry. In 1932 James Chadwick showed that other atomic phenomena would fall into the same order if there was postulated the existence of a heavy fundamental particle without electric charge, the neutron. Once again a new concept unified and gave meaning to the varied and scattered phenomena of nature.

Such profound concepts came to be recognized as products of the scientific mind. In the thought of the twentieth century the scientist might seem more restricted in his freedom than the poet or painter and to be more bound by the facts to which his creativity must conform. But these restrictions do not affect the essence and character of the imaginative process. Relativity, the theory of atomic structure, the concept of the unconscious, the Mendelian laws of inheritance, were seen as works of the imagination. They were triumphs of the human mind, for they found or created order where there was the appearance of disorder, they singled out among the workings of nature certain striking trends, and they imposed an intellectual unity on the lifeless mass of phenomena.[36, 37]

When the twentieth-century scientist was seen to enter so personally into his work and, by implication, its practical consequences, his relationship to society also altered. The change in relation of the scientist to his contemporaries and in his own sense of responsibility grew naturally out of the new sense of science as a personal activity.

VII. SCIENTIST, TECHNICIAN AND LAYMAN

The twentieth century thrust the achievements of its scientists into daily life at a breath-taking rate. The legend of the remote scientist, living in a world of his own thoughts and blundering into discoveries whose practical importance he did not understand, survived only in the comic strips. No scientist of the mid-twentieth century, however abstract his work, could be sure that it would not sooner or later have a technical application. Few would be so rash as to boast, as had the mathematician Godfrey Harold Hardy (1877–1947) in his book *A Mathematician's Apology* (1940), that their work could not conceivably do anyone the least practical harm or the least good. Many physicists had in fact learned their approach to mathematics from the pioneer work of Hardy himself.

Yet the new and remote worlds within the atom, the cell or the universe which the modern scientist explored demanded such specialized knowledge and techniques in order to be perceived that they set the scientist apart from

his fellows. He possessed the key to mysteries as inaccessible to the layman and as crucial to his well-being as those which any priesthood had monopolized in other societies. The public had to depend on him and to give him its trust and support; he, in turn, faced the age-old problem of how to communicate the meaning of his knowledge to those who must act in the light of it and whose actions, in turn, affected his work. For the scientist no longer saw himself merely as a man who supplied others with the facts and left them to make what they could of them. Understanding that what he found, however factual, had practical implications, he came to recognize a responsibility for bringing these implications home to others.

In turn, the practical world influenced the direction of scientific advance. This was not a wholly new development, for the direction in which science has looked, its background interests and its long term problems, have always been influenced by the preoccupations and the needs of the societies in which scientists have worked. Each society and age has created a climate of interest in its special problems. The fundamental scientist, immersed in this climate of interest, has tried his gifts on such of these problems as have challenged his curiosity; and his choice of specific problems may have been more or less directly determined by the existence of facilities for research enabling him to pursue the lines of investigation which he finds challenging.

1. *Support for scientific research*

To an ever-increasing extent during the twentieth century facilities for scientific research were provided by government agencies, industries, professional bodies and private foundations with practical objectives. Universities shifted much of their emphasis from humanistic to scientific studies, and special types of research in universities were often stimulated by subventions from agencies which hoped for usable results.

The most spectacular scientific break-through, the release of energy by atomic fission, and later by fusion, was achieved in direct pursuit of a military objective during and after the second world war. In the decade after the war enormous sums were invested in scientific research by virtually every major country as part of its expenditure for national defence, sums which often overshadowed research expenditures by public or private bodies along other lines.

Such orienting of much scientific research toward defence, although tending to distort its direction, was less narrowing than might at first appear, for total war involved not merely weapons but every other aspect of operation and survival—transport, communication, control of disease, synthetic production of materials, food and agriculture, genetics—in short the whole range of life to which science had been and might be applied. The exploration of outer space, conceived for purely scientific purposes as part of the research programme of the International Geophysical Year, 1957–58, came to be linked with military

efforts to design missiles which could travel through space and re-enter the earth's atmosphere.

As governments expanded their functions they supported research along many other lines, notably public health, agriculture, power, transport, communications and construction, social processes and social problems. Industries spent huge sums for technical research, either within a single enterprise as in the Bell Laboratories of the American Telephone and Telegraph Company, famous throughout the world for work in the field of communications, or in research establishments maintained by groups of enterprises producing steel, petroleum or other fuels, chemicals, plastics, artificial fibres, radios, aircraft or motor vehicles.

Applied research was not confined to practical matters, for it came to be recognized that next steps in application often depended on fundamental scientific discovery, whether of radiation affecting the possibility of travel in outer space or of biochemical factors able to unlock secrets of cancer. Research in the Bell Laboratories, for example, ranged from speech formation to the abstract theory of information. Military research extended into such remote mathematics as the theory of strategic games. Coal research in Britain gave special attention to the fossil flora found in coal. Most strikingly, the work done by Hans Bethe (1906–) and others in the 1930s in elucidating the source of the sun's energy pointed the way to the development of a first bomb in which hydrogen was fused to helium. But theoretical work in Russia, Britain and in the United States at once pressed further than this, and devised a fusion reaction on a new principle. Comparable examples of the close link between fundamental research and practical needs could be found in many fields, including communication engineering and plant breeding.

Several factors tended to make the support of scientific research by government and industry a noteworthy feature of the twentieth century and to increase this tendency with the passing years. As science pervaded more and more aspects of life, societies looked to their scientists to contribute to national survival and well-being; science itself became an instrument of national defence and a means by which national industry could compete in world markets, public health could be achieved, air and road accidents reduced, long-distance communication perfected, agricultural production promoted. In addition the tremendous cost of equipment required for experimental work, especially in the field of nuclear physics and in the exploration of outer space, made generous support essential; even the wealthiest of the American universities found themselves hard pressed to equip laboratories where their nuclear physicists could engage in pioneer research, and several of them joined together after the second world war to support such a laboratory in common. Furthermore, many problems could not be studied effectively by a single scientist but required the collaboration of a group of specialists, and the organization and funds to bring them together and support their work.

The use of scientific theory and technology by governments and industries

brought profound ethical problems to scientists and dangers to the development of science itself. The teamwork necessary for large-scale research not infrequently brought pressures for conformity and discouraged originality and brilliance. Though the interaction of many minds could be stimulating it could also lead toward a consensus of mediocrity which excluded disturbing questions.

Discoveries made by scientists working in industrial laboratories generally became the property of the company, which then could determine their use, and the scientist's contract of employment often restricted his further work along the same line either within or outside of the enterprise. When scientists worked for the government, problems of national security often demanded secrecy. Walls were thus raised around the individual scientist, and loyalty to country brought him into conflict with the most basic of scientific loyalties, the pursuit of truth and the free flow of knowledge.

By no means all scientific discovery in the twentieth century, however, depended on costly experiments or the co-operative work of many specialists. Patience and imagination often proved more important than complex equipment in yielding new scientific insights, especially in the biological and social sciences. Important characteristics of the scattering of light, known as the Raman effect, were discovered by the Indian physicist Chandrasekhara Venkata Raman (1888–) with a minimum of equipment and much careful mathematical work, in 1928.

Even in nuclear physics very significant discoveries continued to be made by theoretical physicists, often working where costly equipment could not be provided. In the 1930s the Japanese physicist Hideki Yukawa (1907–) predicted the existence of mesons on theoretical grounds, before these particles had ever been looked for and before giant machines were built to produce them.

Similarly, two Chinese theoretical physicists, T. D. Lee (1926–) and C. N. Yang (1922–), working in the United States, devised an experiment to test the assumption that atomic phenomena should be symmetrical. Unexpectedly, in 1956, the experiment disproved this basic assumption in physics and opened an exciting new field of study.

Whether the scientist worked alone or in a group, experimentally or theoretically, in academic seclusion or employed by government or industry, his own creative imagination and scientific curiosity remained the driving force leading to new discoveries. And in spite of security regulations, trade secrets and governmental or industrial direction of some research, much freedom for the exchange of information remained, while the nature of science itself constantly called for such exchanges. Regardless of national or other boundaries, scientists continued to share their observations and thus build up a cumulative body of knowledge as they had been doing since the beginning of modern scientific inquiry.

2. *Communication between scientist and layman*

The close link between scientist, technician and layman placed a burden on the scientist to make the implications of his findings clear and understood by others. In the twentieth century this became an ever more necessary and more difficult task. It was more necessary because the impact of science on the life of mankind forced non-scientists constantly to make judgments involving its use, and they needed understanding in order to make such judgments soundly. It was more difficult because of the lack of a language in which scientists could communicate to laymen.

The imperative need for the scientist to bring home to others the meaning of his discoveries was intensified at mid-century by the threat to the very existence of mankind from nuclear explosion and the release of radioactivity. These fruits of scientific effort not only placed on scientists the heavy responsibility of making their implications understood; they faced the scientist with a basic ethical conflict. In choosing what search to pursue and what instruments to make, scientists were forced to think in terms of their ethical duties as well as their duty to uncover laws of nature. The judgment and understanding required of the scientist went beyond his competence as a specialist in his field.

Yet as the sciences grew more specialized and their researches more detailed it became difficult for the individual scientist to present his thought in the total context of science. With his special vocabulary of words and symbols he was often scarcely able to communicate even with other scientists outside his field who also had special vocabularies and symbols of their own. To make the nature and meaning of his discoveries understood by the public was even more difficult.

The difficulty was enhanced by the fact that up to the middle of the twentieth century the new scientific discoveries had not yet yielded a compact organizing principle which could be seen to run through all sciences and would bring order to the scattered disciplines, in the way that the elucidation of the principle of cause and effect had brought order into the scattered knowledge of the seventeenth century.

The absence of such a general principle was a handicap to the scientist, above all, in his relations with the public. For the relations depended on the existence of a language which the scientist felt to be sufficiently accurate and which nevertheless the public could understand. Newton's *Principia* had created such a language of communication between scientist and public for its time, and Darwin's *The Origin of Species* had done so for its period. The principles which underlay these books could be grasped by the public which thus gained an insight into scientific method and a vocabulary of scientific fact.

The language which would make the new science immediate to the public had not yet been created by the middle of the twentieth century; it was an open question whether it could be created until a unifying principle should have been distilled from the revolutionary thoughts in the science of this

century, as the unifying view had slowly taken shape after the first scientific revolution. Meantime, the public remained bewildered by the new science because it lacked a language and the habits of thought which a language formalizes. Thus bewildered, it could not readily exercise its responsibility for the use of the new scientific findings and it sometimes blamed the scientist for making discoveries which could be put to destructive use.

3. *The scientific outlook in daily life*

Yet a scientific outlook did come to penetrate into the daily life of the time and some of the new scientific concepts, at times diluted or distorted, became part of current thought. In areas where the scientific point of view was accepted—and these were constantly growing, both geographically as more people came in contact with modern techniques and in wider areas of daily life—people came to respect facts and to approach them rationally and empirically. This was particularly noteworthy not only in practical matters relating to industry or travel but in the field of health where new knowledge supplanted traditional practices at a strikingly rapid rate.

Perhaps the most significant evidence of the extent to which science had entered the outlook of the twentieth century was the acceptance of change as a continuous and fundamental phenomenon, and adaptation to its accelerating pace. Not only was this true of the western countries where the expectation of change had become a well-established attitude. In the historically more static societies of the East, where change had been looked upon as defection from eternally established norms, it became the order of the day.

Equally fundamental was the concept of new potentialities which science brought and the public accepted. All over the world people who for centuries had taken poverty and disease for granted saw in the methods and the fruits of science a new possibility of human fulfilment. In the first half of the twentieth century this vision altered the outlook of mankind.

Specific concepts from the new science were incorporated into attitudes and thought. Chief among these was the idea of relativity. Though often enough misunderstood, the idea of relativity as a revolutionary concept in physics impressed on moralists, artists and the man in the street the notion that, from other points of view, reality may appear different, and yet be as valid as that which they themselves perceive.

The concept of uncertainty also entered the popular mind and many people learned to think statistically in terms of chance and probability rather than in terms of the certainty of direct cause and effect. Concepts derived from psychological studies of learning and conditioning and Freudian analysis of personality formation entered into the lore associated with the rearing of children. The scientist's sense that the observer is inevitably a part of that which he observes was reflected in the inner perspective of the modern writer. And the fact that physics became concerned with atomic structure also

influenced painters and sculptors to portray what they saw as discontinuous structure rather than as surface appearance.

In the swiftly changing world of the twentieth century science was thus an ever-growing force, constantly yielding new facts and new capabilities which brought changes in structures, activities and relationships, often before it had developed the means to deal with the results of such changes.

The chapters which follow will examine this process in the elaboration of scientific thought and the application of scientific knowledge as the dynamic interplay between knowledge and action remade one aspect after another of the life of mankind.

NOTES TO CHAPTER VI

1. Already at this time many scientists, Dr L. Pollak points out, including men as well known as Helmholtz, Lodge and Stoney, thought that the atom was not simply an indivisible structural element. But as yet there was no direct experimental proof that this was the case.
2. Dr L. Pollak reminds that the development of statistical concepts in the molecular-kinetic theory of gases (Maxwell, Boltzmann), of statistical mechanics (Gibbs), and the statistical interpretation of the second law of thermodynamics (Boltzmann) introduced entirely new elements into physics, which were to play a decisive role in the development of this branch of science during the twentieth century.
3. *The Author-Editors call the attention of the reader to the treatment of probability theory and statistics in Chapter VII, pages 172–3.*
4. Candidate of Philosophical Science A. S. Arsenyev says that L. Kronecker's view of the 'God-given' nature of whole numbers can scarcely be considered characteristic of the mathematicians of the last quarter of the nineteenth century.
5. In the opinion of Academician Ivan Malek the principle of natural selection is explained incorrectly, in a Malthusian fashion. As Karl Marx and Friedrich Engels pointed out, writes Academician I. Malek, Darwin was mistaken in making use of Malthusian ideas and referring to them, but this does not detract from the essential correctness of Darwin's teaching on natural selection.

   Both writers realized how ironical it was that Darwin should apply to animals and plants the anti-humanist Malthusian idea that mankind was multiplying in geometrical progression, while holding that the means of existence, i.e. those very same animals and plants, were multiplying in arithmetical progression—and in this way demonstrate, without realizing it, the absurdity of this idea. In refutation of Malthus' theory it is sufficient to point out that the population of the world, and Great Britain in particular, has risen several times since the time when Malthus wrote, but that the average consumption per head of food products, far from diminishing, has actually increased to a significant extent.

   The 'struggle for existence', i.e. natural selection, as Darwin understood it, is never the consequence of overpopulation. It is rather the reverse: overpopulation, which facilitates the survival of a particular species in conditions unfavourable to existence and development, is itself the consequence of selection; this means that only those species survive which are capable of compensating, by reproduction, for periodical curtailment of their numbers.
6. *The Author-Editors call attention to the fact that the explanation presented in the text is that given by Darwin.*

7. Academician Ivan Malek emphasizes that at the time when Darwin published his work, and even much later, nothing was known about the inheritance of the minor variations which Darwin considered the prime factor in natural selection; nevertheless subsequent discoveries in the realm of genetics have not required any essential corrections to be made to the theory of natural selection, with one exception: we now know that some of these minor variations, and in particular those included in the concept of instable variability, are not heritable and therefore cannot be subjects of selection. On the other hand, study by geneticists of natural populations of animals and plants has revealed a fairly large number of heritable variations—the so-called micro-mutations.

8. Candidate of Historical Sciences J. P. Averkieva points out that by this time there had already appeared such classical works on the history of primitive society as L. Morgan's *Ancient Society* (1877) and F. Engels' *The Origin of the Family, Private Property and the State* (1884).

9. Candidate of Juridical Sciences A. E. Bovin reminds that a work which appeared much earlier than that mentioned in the text, and which was far more profound in scope, was F. Engels' *The Condition of the Working Class in England* (1845).

10. In the opinion of Soviet scholars, the assessment given in the text of the scientific legacy of Karl Marx is incomplete and essentially erroneous.

Prior to Marx and Engels the realm of social phenomena was considered an unassailable citadel of idealism. All philosophers were convinced that what determined the life of a society were men's ideas and the struggle between them. Of course, one can detect individual elements of a Marxist approach to society in the views of a number of predecessors of Marx: among the French materialists, the advanced British economists, Feuerbach, Hegel, and the utopian socialists. But these were only surmises which did not alter the general situation—the complete domination of idealism over matters concerning human history.

Marx and Engels overcame idealism in this sphere as well, by applying dialectical materialism to social phenomena and creating the theory of historical materialism. The main significance of this theory lies in the fact that it turned the study of society and its laws into a science, which like other sciences was capable of providing precise data, on the basis of which the course of events could be predicted and social development guided in the necessary direction. In evolving the theory of historical materialism an important part was played by an examination of capitalist society. Far more graphically than other social formations, capitalism and the class struggle between the proletariat and the bourgeoisie revealed the contradictions of material interest that underlie the antagonism inherent in any class society. As Marx and Engels wrote in the *Communist Manifesto*, the bourgeois epoch had 'simplified the class antagonisms'; it has substituted for exploitation veiled by religious and political illusions 'naked, shameless, direct, brutal exploitation'. Their profound objective analysis of the capitalist system refuted the idealist conception of history and led to the incontrovertible conclusion that the main motive force in the development of society is not reason, not ideas, but material needs, the production of material values. This investigation into the motive force of capitalist society also threw light on the whole of man's past. The anatomy of the bourgeois system could, in a manner of speaking, provide a key to the anatomy of the entire previous development of society. Marx and Engels showed that in the development of society, as in the world of nature, there existed objective laws independent of the consciousness and will of men. They discovered the general laws governing all social progress. This is the content of historical materialism.

The emergence of historical materialism, as a science elucidating the laws of social development and a method of studying social phenomena, was not the product of mere chance but of the logical development of society and scientific philosophical thinking. Previously the inner link between social processes, between the causes of historical events and the events themselves, had been obscured from view and therefore difficult to discover; but with the development of capitalism this link was becoming more and more simple and obvious.

The course of history was accelerating. From the English Revolution onwards, and particularly after the French Revolution of 1789–94, events followed upon one another

with great rapidity; class contradictions were becoming sharper; clashes took place, and the working class appeared upon the stage of history. These were the social premises that made possible the creation of the science of the laws and motive forces governing social development. The tempestuous events of the late eighteenth and early nineteenth centuries showed that human society had not crystallized into a form valid for all time, but was changing and developing. Although the course of history was marked by certain zigzags, by and large the trend of social development was, and is, upwards.

Advanced social thinkers such as Hegel, the British classical political economists, British and French historians of the 1830s and 1840s, and some pre-Marxist philosophical materialists (Helvetius and others) were feeling their way towards a scientific view of society and history. But everything done in this sphere before Marx was purely tentative—an approach to a correct scientific attitude, but not a scientific theory, not an integral well-founded view of the historical process. The creation of historical materialism was the great scientific achievement of Marx and Engels—an exploit that had world-historical significance for the theory and practice of revolution, for the cause of communism. Marx and Engels were only able to create historical materialism and Marxism as such because they were the ideologists of the most progressive class in society—the working class, which was interested in discovering the truth, in the forward march of society, and not in perpetuating old outmoded social relationships.

Historical materialism arose as the result of the application of dialectical materialism to society and the study of social phenomena, and to the history of society. For this reason the laws and categories of historical materialism cannot be understood in isolation from the tenets of dialectical materialism. Thus, for example, when studying the laws governing the movement of class societies, which historical materialism discovered, the law of class struggle and social revolution, it should not be overlooked that these laws constitute one specific form of the universal dialectical laws of the unity and conflict of opposites, the struggle between old and new, positive and negative, and the transformation of quantitative changes into qualitative change.

In conformity with the general materialist world outlook historical materialism proceeds from the assumption that social being is primary and social consciousness secondary, or—to put this in another way—that it is not ideas that determine life, but life, social existence, that determines ideas. But what do we mean by 'social being?' We mean the material life of society, and in the first instance the social production of material values and the relations formed between men in the course of production. In an antagonistic society these relationships are relationships between classes. Before men can occupy themselves with science, art, religion, philosophy or politics, they have to drink, eat, clothe themselves—and for this they have to produce foodstuffs and clothing, build houses, and create means of production. Without the production of material values social life is impossible. The production and reproduction of material values constitutes the vital foundation of a society. If production were to cease all intellectual and spiritual activity would become impossible and society would perish. Therefore the key to the structure and development of society must be sought, not in men's consciousness, not in their political, philosophical, religious, or moral ideas, but in the mode of producing material goods.

The material life of society is basic and determinant, whereas spiritual life is reflection of material life. This by no means implies, as bourgeois critics of Marxism falsely assert, that Marxists underestimate or play down the significance of the spiritual life of society, the role of ideas, consciousness, reason, science, art, or politics in social life or history. On the contrary: by declaring social consciousness, social and political theories to be a reflection of social being, Marxists are thereby simply giving a scientific explanation of the spiritual life of society, the origin and development of ideas. Marxists consider that social ideas play a very important part in the life and development of society. It may be added that the bourgeoisie has had to pay for its vulgar superficial ideas about Marxism, and in particular about historical materialism. Thousands of nonsensical treatises have been written criticizing Marxism and blowing it to smithereens on the grounds that it allegedly ignores or minimizes the role of ideas, ideals, the spiritual element, and so on—and now the bourgeoisie has suddenly discovered that Marxist ideas, the ideas of communism, are spreading more and more widely and possess irresist-

ible force. Bourgeois politicians and ideologues have therefore raised a cry about 'pernicious' communist propaganda and 'subversive' activity by communists. At the present time the bourgeoisie is compelled to admit more and more frequently that it has no great ideas which it could put forward in opposition to the ideas of communism. The classical formulation of the basic principles of historical materialism was given by Marx in the preface to his book *A Contribution to the Critique of Political Economy*: 'In the social production of their life men enter into definite relations that are indispensable and independent of their will, relations of production, which correspond to a definite stage of development of their material productive forces. The sum total of these relations of production constitutes the economic structure of society, the real foundation, on which rises a legal and political superstructure and to which correspond definite forms of social consciousness. The mode of production of material life conditions the social, political and intellectual life process in general. It is not the consciousness of men that determines their being, but, on the contrary, their social being that determines their consciousness.

'At a certain stage of their development the material productive forces of society come in conflict with the existing relations of production, or—what is but a legal expression for the same thing—with the property relations within which they have been at work hitherto. From forms of development of the productive forces these relations turn into their fetters. Then begins an epoch of social revolution. With the change of the economic foundation the entire immense superstructure is more or less rapidly transformed.

'In considering such transformations a distinction should always be made between the material transformation of the economic conditions of production, which can be determined with the precision of natural science, and the legal, political, religious, aesthetic or philosophic—in short, ideological forms in which men become conscious of this conflict and fight it out. Just as our opinion of an individual is not based on what he thinks of himself, so can we not judge of such a period of transformation by its own consciousness; on the contrary, this consciousness must be explained rather from the contradictions of material life, from the existing conflict between the social productive forces and the relations of production. No social order ever perishes before all the productive forces for which there is room in it have developed; and new, higher relations of production never appear before the material conditions of their existence have matured in the womb of the old society itself. Therefore mankind always sets itself only such tasks as it can solve; since, looking at the matter more closely, it will always be found that the task itself arises only when the material conditions for its solution already exist or are at least in the process of formation' (K. Marx, *A Contribution to the Critique of Political Economy*, Karl Marx and Frederick Engels, *Selected Works in Two Volumes*, Moscow Foreign Languages Publishing House, 1958, Vol. I, pp. 362–3). These propositions were formulated one hundred years ago. The whole subsequent course of social development, all the foremost and greatest events of our time, and in the first place the victory of socialism in the USSR, the people's revolution in China and other countries of Europe and Asia, where socialism is being successfully constructed, have confirmed wholly and fully the laws of social development discovered by Marx and Engels.

11. Candidate of Philosophical Sciences A. S. Arsenyev points out that the authors mistakenly equate mechanistic determinism with determinism as such. Furthermore, A. Arsenyev adds, already at that time the materialistic dialectic was in existence, and this provided the means for a much deeper understanding of causality.

12. Candidate of Philosophical Sciences A. S. Arsenyev reminds that the quantitative principle was criticized from the dialectical point of view, by Hegel, already at the beginning of the nineteenth century—and not in the twentieth century, as the authors write. The correct solution of the problem of quality and quantity was given not by the natural sciences, but by philosophy.

13. Candidate of Philosophical Sciences A. S. Arsenyev reminds that the authors regard the principle of continuity as one of the principles of the scientific method of the eighteenth and nineteenth centuries. It is necessary to add that the question of continuity and

discreteness has been solved by the dialectic. What the authors present as the modern point of view (recognition of discreteness alone) is a one-sided abstraction, just as erroneous as its counterpart.

14. Candidate of Philosophical Sciences A. S. Arsenyev points out that the 'principle of personality' adduced by the authors in opposition to the principle of 'impersonality' in fact implies a subjectivist concept of science verging on apriorism.

15. Candidate of Philosophical Sciences A. S. Arsenyev thinks that this is not true. The theory of relativity does not explain the result of the Michelson experiment—i.e. it does not give it any physical interpretation. It presents it without contradiction, provided that certain limiting postulates are imposed on the physical world.

16. Dr L. Pollak considers that this statement is misleading unless the following is added: In 1924 L. de Broglie developed the idea that matter could behave either as a wave or a corpuscle, putting forward the hypothesis that each particle of matter (electron, etc.) also has the properties of a wave. In 1926 E. Schrödinger worked out the theory of the wave mechanics of the atom. According to this theory the behaviour of an atomic structure could be examined and explained with the aid of a kind of wave function.

    Max Born showed that this function could be interpreted as giving a certain measure of probability that a particle exists at a particular point in space at a particular moment in time. Many idealist philosophers, without any serious scientific foundation, have linked Schrödinger's probabilist interpretation of wave function with an indeterminist concept of the microcosm.

17. László Mátrai, Corresponding Member, Hungarian Academy of Sciences, writes that it is incorrect to say the non-Euclidean spaces were first studied by followers of Corrado Segre, whose work was based on that of Hermann Grassman. It is generally acknowledged that the first in the field were Bolyai and Lobachevsky.

18. *The Author-Editors call attention to the fact that the text does not make the statement attributed to it in the preceding note.*

19. Candidate of Philosophical Sciences A. S. Arsenyev reminds that fruitful systems of non-Euclidean geometry were also elaborated by N. I. Lobachevsky (1792–1856) and J. Bolyai (1802–60).

20. *The reader is referred to Chapter VII, p.* 169, *for discussion of non-Euclidian geometry.*

21. Doctor of Biological Sciences P. Henckel asserts that K. A. Timiryazev was one of the first to point out that the nature of heredity is to be ascertained, not by establishing statistical patterns, but by physiological studies. He noted that the rules set down by Mendel are not universal. Timiryazev offered a classification of heredity, distinguishing between simple and complex heredity. Simple heredity is observed during vegetative reproduction, and complex, in crossing. According to Timiryazev, complex heredity is subdivided into: (1) mixed heredity, when one part of the organism displays the traits of one parent, and the other part, of the other parent: (2) merged heredity, when the traits of the parents are merged, giving rise to new traits; (3) mutually excluding heredity, when the traits of one parent alone are displayed. In this latter type, two categories of cases are observed: (*a*) when the offspring shows no variety (Millardism) and (*b*) when the offspring does show variety, usually beginning with the second generation (Mendelism). The work and achievements of Michurin's genetics have confirmed Timiryazev's view of heredity and have yielded important practical results in the field of plant and animal selection.

22. Doctor of Biological Sciences P. Henckel writes that major changes in the nature of organisms are not always attributable to alteration of the number or structure of chromosomes.

23. Doctor of Biological Sciences P. Henckel points out that viruses were discovered by the Russian scientist D. O. Ivanovsky, who specialized in plant physiology. He was the first to demonstrate, on the basis of studying the tobacco mosaic virus, the corpuscular nature of viruses and to describe the crystalline insertions of viruses (Ivanovsky's crystals) in the cells of a diseased plant.

24. Candidate of Biological Sciences L. Ya. Blyakher expresses astonishment and concern that the authors should apparently be inclined to question whether all biological phenomena are at all times susceptible to a materialist explanation.

25. *The Author-Editors note that the text expresses no view on this matter.*

26. Doctor of Historical Sciences Yu. P. Averkieva underlines that Freud's theory is a speculative one: its propositions are based in the main on the intuition and imagination of the investigator, and not on rational methods of experiment worked out in detail. This theory has never enjoyed much success in Eurasian countries, and especially not in the Soviet Union. The authors ought to emphasize that modern neo-Freudianism, like Freudianism in the past, is most widespread in the USA, but that even there it is being subjected to well-founded criticism, not only by sociologists and ethnologists, but also by psychologists. See, for example, Yu. P. Averkieva, 'Etnofreidizm v S.Sh.A.' (Ethnofreudianism in the USA), *Sovetskaya etnografiya* (Soviet Ethnography) (1962), No. 4, pp. 3–15; H. Wells, *Pavlov and Freud* (New York, 1956); R. Piddington, *An Introduction to Social Anthropology* (London, 1957), Vol. 2; O. Klineberg, 'Tensions affecting International Inderstanding', *Social Science Research Council Bulletin* (1950), No. 62.

27. Doctor of Historical Sciences Yu. P. Averkieva writes: In this section the authors state that the investigations of ethnologists and students of folk-lore at the beginning of the twentieth century allegedly 'undermined' faith in the doctrine of social evolution created by Morgan, Taylor and others; furthermore they justify the anti-historical approach to the study of social history employed by the functional school of bourgeois ethnologists, with their relativism and conception of holism. This approach is at present rejected by most Western scholars, who have made a sharp turn towards the theory of evolution. The anti-historical trend and its worthlessness from a scientific point of view are examined in the following works: D. A. Olderogge and I. I. Potekhin, 'Funktsionalnaya shkola v etnografii na sluzhbe britanskogo imperializma' (The Functional School in Ethnology at the Service of British Imperialism) in the volume of essays entitled *Anglo-amerikanskaya etnografiya na sluzhbe imperializma* (Anglo-American Ethnology at the Service of Imperialism) (Moscow, 1951) pp. 41, 66; J. Steward, *Theory of Culture Change: Methodology of Multilinear Evolution* (Urbana Ill., 1955); *Evolution after Darwin* (Chicago, 1960), Vol. II; F. Voget, 'Man and Culture' *American Anthropologist* (1956), Vol. 58, No. 6.

28. *For a fuller discussion of the various trends in anthropology in the twentieth century, see Chapter XVI,* infra, *and Clyde Kluckhohn, 'Anthropology in the Twentieth Century' in* Journal of World History, *III, 3 (1957), pp. 754–77.*

29. Doctors of Physical and Mathematical Sciences E. Adirovich and R. Steinman give the following estimation of Sections IV, V and VI: In these sections, the authors seek to demonstrate that there is a radical difference between the science of the twentieth century and that of the eighteenth and nineteenth centuries. It is pointed out in the text that the most important scientific achievements of the twentieth century are the quantum theory and the theory of relativity, although the account of the former is confined to an account of the principle of indeterminacy, and the theory of relativity is considered solely from the angle of the role of the observer. The authors say almost nothing at all about the most important achievement of twentieth-century physics: the creation of the physics of elementary particles. Yet this is a major revolutionary step towards the establishment of a single physical picture of the world, a single theory of matter. The discovery that many elementary particles change into one another according to certain laws and form systems combining matter and field has thrown much light on the way in which particles interact upon one another, and has shown the connection between different types of matter and the types of motion and interaction associated with them. The theory of relativity has shown that space and time are inter-connected, and also connected with the distribution and movement of masses—which the authors, incidentally, ignore completely, since they say nothing at all about the general theory of relativity. Quantum mechanics, and in particular quantized field theory, the fundamental ideas of which are also overlooked in Chapter VI, have led to a re-examination of the

questions of the particle and its dynamical motion, the limitations of the concept of the individual in nature, and the correlation of the movements of identical particles forming a single system.

The basic ideas of twentieth-century physics are set out here in accordance with the canonical scheme of positivist ideas (collection of measurable magnitudes instead of study of the objective world; hyperbolization of the relationship between uncertainties, and treatment of this as signifying a limitation of the possibilities of cognition, instead of the inadequacy of macro-characteristics when dealing with micro-particles; the concept of the observer bringing order into the phenomena he studies; the concept of chance as lack of causality, etc.). A reader of this chapter would draw the conclusion that such treatment is generally accepted, and is even the sole possible interpretation that could be given to the findings of modern physics. But one may refer, for example, to the works of Blokhintsev, Fock, de Broglie, Bohm and other scientists, whose views, however different they may be from one another, are at sharp variance with the conception put forward in Chapter VI. The modern scientific ideas contained in this chapter, presented as characteristic of the modern world-outlook and modern scientific method, are in fact nothing more than negative demonstration of the inadequacy of the principles underlying the old metaphysical method. Moreover, the ideas put forward here as characteristic of the modern scientific world-outlook (for example, the ideas of indeterminism, uncertainty, the 'personal' character of science, etc.) in reality testify to the absence of proper scientific method. They lead science into a blind alley, and in the last resort to the revival of theology. At the same time the text of this chapter contains not a word about the materialistic dialectic, which solves the questions of the relationship between chance and necessity, between relative and absolute truth. Many natural scientists abroad are evidencing great interest in the materialist dialectic. It is gradually becoming, and in future undoubtedly will become, the generally accepted method of scientific inquiry. For the moment, however, in science a stubborn ideological struggle is in progress—one which has not been reflected by the authors of Chapter VI.

30. *The Author-Editors call the reader's attention to the language of the text, pages* 130 *and* 146. *The account on pages* 143–150 *is an exposition of the inadequacy of macro-descriptions when applied to micro-particles and to micro-phenomena. It does not deal with individual theories (for example, that of de Broglie and that of Bohm) which attempt, in different ways, to set up new systems of description for the behaviour of micro-particles. For fuller treatment of elementary particles, see Chapter VIII, pp.* 194–203. *For the General Theory of Relativity, see page* 151.

31. Candidate of Philosophical Sciences A. S. Arsenyev writes that in making this statement the authors are making the law of nature dependent upon the observer, i.e. they are assuming that matter does not exist objectively, independently of the observer. It does not make any difference if one substitutes all observers for a single observer: this merely leads to the Bogdanovist concept of truth as 'socially organized experience' (truth is what everyone agrees to be true).

32. *The Author-Editors call the reader's attention to the exact language of the text, which does not deal with the metaphysical question of the independent existence of matter apart from the observer but with the nature and basis of the observer's knowledge. See also pages* 149 *to* 152.

33. Doctor of Physical and Mathematical Sciences E. I. Adirovich and Dr R. Steinman think that Neumann's theorem of concealed parameters, which stated that it was impossible to describe a system 'fully' within the framework of quantum mechanics, is incorrectly treated by the authors as proof that the views put forward in Chapter VI are the only possible treatment of the findings of modern physics. In actual fact the essence of the matter lies, not in our supposed inability in principle to obtain complete knowledge, not in 'the inexactness of measurements', but in the objective absence of the possibility of an absolute isolation of an individual (of a particle or a system) from external impacts; this accounts for the non-universality of dynamic regularities.

34. *By way of clarification, the Author-Editors note that von Neumann's theorem is presented only as a confirmation of the inability to make exact forecasts of small-scale events.*

35. László Matzai, Corresponding Member, Hungarian Academy of Sciences, thinks that the authors are clearly exaggerating the differences between the scientific thought of the twentieth and nineteenth centuries. It is not as though there were an unbridgeable gulf between classical and modern physics. Lorentz's transformations make possible an exact transition from one system to the other. It is highly symptomatic that Lorentz's name is not even mentioned as one of the greatest physicists of our age.

In general the authors' interpretation of Einstein's theory of relativity is dangerously close to philosophical relativism and even to subjective idealism.

36. Doctor of Historical Sciences Yu. P. Averkieva points out that Soviet scientists are astonished, to say the least, to find the semi-scientific Freudian concept of the unconscious included among the triumphs of the human mind together with the theory of relativity and the theory of atomic structure. As has already been pointed out in the note 26, *supra*, Freudianism is only popular in the USA, and can therefore lay no claim to a place among the theories and concepts that have had a global impact. See also *Sounemennaya amerikanskaya etnografiya: sbornik statey* (Contemporary American Ethnography: Collection of Articles) (Moscow, 1963); H. J. Wells, *Pavlov and Freud* (New York, 1956).

37. *For the influence of Freud in countries other than the United States, see references* in Note 3 of Chapter XVI *and the following: Benjamin Nelson,* Freud and the Twentieth Century (*New York: Meridian Books, 1958*), *Leopold Bella, ed.*, Contemporary European Psychiatry (*New York: Evergreen Books, 1961*).

CHAPTER VII

MATHEMATICS AND LOGIC*

DURING the twentieth century a profound change took place in the understanding of the nature of mathematics and in particular of its connections with logic and with physical reality. It was beginning to be clear that this change marked one of the most significant intellectual advances in the history of mankind, the full implications of which could not be prophesied.

The brilliant and varied achievements of twentieth-century mathematicians tended in some measure to obscure the revolutionary character of the underlying mathematical currents of the times. And furthermore, the recognition of the true state of mathematical affairs was not altogether easy because it was not apparent just when or where mathematicians made so clean a break with the past as the physicists did around 1900. In the history of modern physics the price which had to be paid for the new knowledge of the atom and the nucleus was the virtual abandonment of the theoretical foundations of physics as they had been painstakingly elaborated up to the end of the nineteenth century. In mathematics nothing so drastic or so spectacular took place. On the contrary there was a continuous and on the whole accelerated development from the sixteenth century to the mid-twentieth century, when mathematical activity attained a volume and an intensity the like of which had never been seen before.

The new conception of mathematics evolved bit by bit in the midst of this increasing activity, growing quite naturally and logically out of the discoveries of earlier mathematicians, particularly those of the nineteenth century. It provided new insights and a radically different philosophical attitude towards the role and the responsibilities of the mathematician without requiring that he abandon the principal achievements of earlier generations or reject the successful working practices and techniques of his predecessors. The emergence of the new ways of thinking about mathematics was too recent to permit an adequate appreciation of how profoundly they might alter the course of mathematical development. Nevertheless they had already produced clearly observable effects in stimulating and strengthening creative work in pure mathematics, and they promised to exert a strong overt influence upon the multiplying uses of mathematics in understanding and controlling the phenomenal world for human ends.

While the changes in mathematics represented some of the most far-reaching and significant changes produced in the course of the century, they were not of a kind to strike a casual observer with the same force as many

* This chapter was prepared by Dr. Marshall E. Stone.

others which accompanied them and which were indeed more or less directly caused by them. If the educated public by and large was reasonably well aware of the revolution which shook the foundations of physics, the same could hardly be said in reference to mathematics. Relatively few had any comparable knowledge or grasp of the fundamental progress which had occurred in the latter field. For the majority of mankind, chiefly concerned with the practical impacts of science and little or not at all with its intellectual roots, the most striking and impressive changes were those which impinged directly, intimately and decisively upon men's daily lives.

The powerful influences let loose by modern science were already beginning to affect society as a whole in such drastic ways that their true import could be grasped only by interpreting them as the agents and determinants of an entirely new and different cultural stage in the evolution of the human species. But beneath this transformation and subtly moulding the evolution of its consequences lay the potent role of mathematics whose influence bade fair to become ever more powerful and pervasive in science and in the other affairs of men. For the perception of new mathematical patterns in nature and of new forms in mathematics itself lies at the root of all science and all its applications.

The emergence of mathematics in the twentieth century upon an entirely new level of thought and action finds a unique and striking parallel in the history of Greek mathematics. The fundamental new discovery made by the Greeks, on which the whole edifice of their mathematics rested, was that the facts of empirical geometry fall into a logical pattern, accessible to description and analysis in terms of logic alone. In the relatively short span of two or three centuries the mathematicians of ancient Greece succeeded not only in grasping the logical structure of geometry but also in developing logic itself as a powerful tool for the discovery of new mathematical propositions. In spite of having left unsettled a certain number of details which actually were not put entirely straight until the end of the nineteenth century, they had done the essential things needed to show that geometry, far from being a strictly empirical science, can be developed from a few empirical axioms solely by means of logical inference. This was beyond all doubt or argument one of the few outstandingly great achievements of the human intellect. The mathematical insights of Thales and Pythagoras had a profoundly stimulating effect far beyond the bounds of mathematics itself and, from the beginning, exercised a powerful directive influence upon the historical development of Greek thought.

The new insights gained during the twentieth century had in essence exactly the same kind of deep fundamental significance for mathematical science as those of the early Greek mathematicians in the sixth century B.C. A comparison with the pioneer period in Greek mathematics strengthened the confidence of mathematicians that the intense and remarkably successful mathematical activity of the day was but a prelude to a still more brilliant era in the development of mathematics.

I. DIVORCE OF MATHEMATICS FROM THE PHYSICAL WORLD AND IDENTIFICATION WITH LOGIC

According to their understanding of the essential nature of mathematics, twentieth-century mathematicians identified mathematics as the study—comparative as well as intrinsic—of general abstract systems, each one an edifice built of specified abstract elements and structured by the presence of arbitrary but unambiguously specified relations among these elements. They recognized further that neither these systems nor the means provided by logic for studying their structural properties have any direct, immediate or necessary connection with the physical world, beyond what may be implied by the statement that thought takes place in the brain. In short, mathematicians reached what is to all appearances the ultimate stage of generalization and abstraction in their modern characterization of mathematics.

To describe the virtually absolute divorce thus permanently established between mathematics and the phenomenal world, Bertrand Russell said that in mathematics we do not know what we are talking about nor whether what we say is true. Because of the purely formal character thereby attributed to mathematics it is appropriate to liken mathematics to a game—or better, to an infinite assortment of games—in which the pieces and moves are intrinsically meaningless and the interest lies in perceiving and utilizing the patterns of play allowed under the rules. It was significant of the profound change which took place in mathematics that more and more mathematicians were approaching their subject in a spirit indistinguishable from that in which a devoted chess-player regards his beloved game. How sharp was the contrast between the twentieth-century attitude and that of earlier generations may be appreciated by recalling the pioneering achievements of such eighteenth- and nineteenth-century mathematicians as Leonhard Euler (1707–83), Pierre Laplace, Augustin Cauchy (1789–1857) and C. F. Gauss in various branches of applied mathematics. In the modern scientific life of the twentieth century pure mathematics was distinguished from applied, and the pursuit of mathematics for its own sake was recognized as a natural, fruitful and culturally desirable form of human activity.

As mathematics thus loosened its ties with the direct study of nature, it formed much closer ones with logic. In fact the line of demarcation between mathematics and logic was almost entirely erased by researches completed during these fifty years. On the one hand the modern characterization of mathematics reduced mathematics to the application of logical procedures to entities—namely, mathematical systems—which can be completely described in the language of logic. Thus all of mathematics was subsumed, in a precise technical sense, under logic. On the other hand the formalizations of logic through the use of appropriate symbolisms led directly to associations (on the meta-mathematical level, at least) with certain mathematical systems—specifically, for instance, with Boolean algebras, polyadic Boolean algebras

or other somewhat similar algebras. Thus logic, in its formal or symbolic aspect, assumed more and more the character of a special branch of mathematics.

It is worth while retracing the evolution of this view of mathematics as a totally abstract, strictly logical and fully independent discipline. The starting-point was the dissatisfaction felt even in antiquity with the parallel axiom of Euclid according to which, in the geometry of the plane, a point and a line not incident with one another determine exactly one line incident with the given point and not incident with the given line. Does this statement reflect a self-evident property of points and lines in the physical sense? Does it or does it not follow logically from their other properties as summed up in the remaining axioms of the *Elements*? In seeking to answer these questions Girolamo Saccheri (1667–1733) discussed in the manner of Euclid a series of interesting consequences to an alternative for the parallel axiom, arriving finally at one which asserted a property of the line in his view 'repugnant to the nature of the straight line'. With this he congratulated himself upon having vindicated Euclid's inclusion of the parallel axiom among the postulates for geometry. What he had actually done was to show that the parallel axiom could be replaced by another which he felt to be more 'natural' and 'self-evident', and because he did not push this exercise of his logical faculties quite far enough he missed an opportunity to discover non-Euclidean geometry.

This opportunity was fully appreciated and seized upon in the early nineteenth century by Wolfgang and Johann Bolyai (1775–1856 and 1802–60), Carl Friedrich Gauss and Nikolai I. Lobachevski (1793–1856) who independently discovered hyperbolic non-Euclidean plane geometry, in which the parallel axiom is not satisfied. Gauss hesitated to publish his results, thus leaving the honours of this important discovery to be shared by the Bolyais and Lobachevski. Gauss sought to decide by physical measurements whether the geometry of space is Euclidean or Lobachevskian, using as a criterion the angle sum of a triangle (which is two right angles in the first case but less than two right angles in the second). He concluded that measurements of the accuracy he could attain were incapable of producing a decision.

Thus two internally consistent but mutually incompatible mathematical systems were available for describing physical geometry. It was impossible to imagine that either of them had, at the expense of the other, the advantage of a necessary connection with the physical world. It was likewise impossible to choose between them, then or conceivably for a good many years to come, on the basis of physical observations. The development of projective geometry by Jean Victor Poncelet (1788–1867), Georg F. Riemann's formulation of a general theory of space within the framework of metric differential geometry, and the comparative study of these different geometries by such eminent mathematicians as William K. Clifford (1845–79), Arthur Cayley (1821–95) and Felix Klein (1849–1925) all contributed to the emergence of the modern view described here.

As in geometry, so also in algebra it became evident that mathematics has to deal not with one number system but with infinitely many, displaying many common features but at the same time having their individual peculiarities. Among these the real and complex number systems remained the ones of principal interest for geometry, analysis and mechanics, though the role of other number systems in geometry began to emerge at the end of the nineteenth century as a consequence of the axiomatic studies undertaken at that time, and thereafter they became well established and familiar.

The increasing variety in mathematics and the technical difficulties met in connection with handling new problems, above all in mathematical analysis, led to an intensified interest in logic and its relation to mathematics. The result was the rapid development of new methods and new concepts which marked substantial advances and shed much light on many difficult or subtle problems in these fields. The symbolic treatment of logic by George Boole (1815–64), Ernst Schroeder (1841–1902) and Giuseppe Peano, the creation of set theory and transfinite number theory by Georg Cantor (1845–1918), and the logical analysis of the real number system by Julius Dedekind (1831–1916) and Gottlob Frege (1848–1925) prepared the way for Bertrand Russell and Alfred North Whitehead's monumental treatise *Principia Mathematica* (1911) which established in minute detail the central facts concerning the identification of mathematics with logic.

These, briefly, were some of the main steps toward the perception of mathematics as an entirely abstract discipline inseparable from logic. It is difficult to imagine how this view might be further developed and modified, except through the development and modification of views concerning logic itself. Thus in a certain sense the process of rendering mathematics abstract, which started in prehistoric times when men first began to conceive that numbers could be detached from the objects they were used to enumerate, reached a more or less definitive stage beyond which it is not possible to go without probing still more deeply into the nature of logic.

II. RELATION BETWEEN PURE MATHEMATICS AND APPLIED FIELDS

The establishment of a new relation between pure mathematics and applied involves an accommodation which would have been forced, quite apart from theoretical considerations, by the increased specialization resulting from the struggles of mathematicians to cope somehow or other with the extremely rapid growth of mathematical and scientific knowledge. Paradoxically, the more uncompromisingly mathematics was conceived as being in principle independent of its applications, the more did productive contacts between mathematics and other scientific fields multiply and flourish. The cultivation of the abstract seemed to lead to success in handling the concrete, no doubt because independence implies a greater degree of flexibility in forming

contacts between pure mathematics and the areas where it may be applied. The more that is known about mathematical systems on their own account, the more numerous are the opportunities for making mathematical progress in fields where traditional forms of mathematical analysis have so far proved inadequate or powerless. A long experience has taught that the working contacts between pure mathematics and applied are mutually beneficial, each influencing the other in stimulating and fruitful ways.

This lesson was confirmed in the twentieth century. In theoretical physics, for example, mathematics was called on to play new and unexpected roles in relativity theory, quantum theory and field theory, all of which were developed in this period. Some of the mathematics required in the study of these branches of physics was already available even though previously little studied or applied by physicists. In particular, tensor analysis, spectral theory and group theory were all in relatively advanced stages of development before being put to use in these newer parts of physics. As a result of the interest aroused by their important new applications, both spectral theory and group theory were stimulated to new growth in the period after 1930.

The mathematical structures abstracted from observation and experience as models for certain aspects of the physical world—a Riemannian geometry of the space-time manifold in the case of large-scale phenomena, and an algebra of operators on Hilbert space in the case of the small-scale realm of atomic and nuclear phenomena—were the most complex and elaborate encountered in any branch of applied mathematics up to the middle of the century. The models used in treating the classical parts of physics such as the dynamics of continuous media (solids, liquids and gases) and statistical mechanics are certainly considerably simpler, in spite of the fact that they offer mathematical difficulties with which mathematicians were still unable to cope. In other fields of science the models developed tended to be still simpler; in some areas, such as the behavioural sciences, mathematics was only beginning to play a role and had not yet been drawn upon for anything but extremely modest contributions. In view of the tremendously complex situations with which the behavioural sciences have to deal, however, it seemed probable that the initial appeal to quite simple and elementary mathematical models would open the way eventually to theories fully as complicated and mathematically involved as those accepted in modern physics.

One of the exciting features of intellectual life in the twentieth century was the proliferation of applied mathematics in a great many different directions, some of which were already indicated by the researches of the preceding century and some of which were entirely new. Because of its close relationship to physics, chemistry was strongly influenced by the radical developments in physics, particularly in so far as the molecular domain is concerned; in some respects the boundary lines between physics and chemistry may even be said to have disappeared, once an effective theoretical understanding of the behaviour of molecules had been made possible through the application of the

appropriate kinds of mathematics. The newer discoveries in biochemistry were undoubtedly preparing a similar demolition of the frontier barriers between chemistry and physics on the one hand and certain branches of biology, particularly genetics, on the other. The analysis of genetic phenomena on the basis proposed by Mendel was given an elaborate mathematical form during the first part of the twentieth century; the next step lay in the search for the mathematical mechanism which enables giant molecules to act as the carriers of hereditary traits.

The study of human behaviour had inspired a certain number of efforts towards the use of mathematics as a tool of analysis before the end of the nineteenth century, but only in the second quarter of the twentieth century was enough success achieved to inspire a fairly large-scale attempt to put this study on the same basis as the natural sciences. The kinds of model used in these pioneering attempts were often quite different from those employed in the older sciences and in more than one instance even required the creation of new branches of mathematics. The most conspicuous example is von Neumann's theory of games, which provides a penetrating analysis of a wide variety of competitive situations and has direct applications in the theory of economic behaviour. But communication theory, though more closely connected with classical mathematics and originally developed with an eye upon engineering applications, was providing insights fully as valuable into the nature and use of language. It would be impossible to catalogue here all the aspects of human behaviour for which mathematical models were proposed during these years, but by way of illustration one or two more might be mentioned—for instance the learning process and some general features of social organization.

At mid-century many of the applications of mathematics suggested as aids to the analysis of men's behaviour as individuals or as members of social groups were speculative, and were a long way from being brought to the point of sharpness and precision which can reasonably be expected of them before they may be considered fully successful. In many cases the mathematical discussion of proposed models was too difficult and the opportunities for collecting appropriate observations too rare for this gap between theory and practice to be easily narrowed in a satisfactory way. Nevertheless, a plausible speculative analysis in terms which can be subjected to something a little better than trivial logical transformations is often very helpful in trying to grasp a complex situation, long before any detailed inferences can be drawn. For this reason there is justification for thinking that substantial progress in the mathematical treatment of the social sciences was being made from the 1930s on.

A feature common to many of the mathematical models which were introduced in widely different sciences was their incorporation of the basic concepts of probability theory. For this reason they are generally called statistical models and their mathematical study requires the use of techniques

developed in the theory of probability and statistics. While most of these statistical models were proposed during the twentieth century, the idea of using them was a discovery of earlier times. Thus the statistical model on which the kinetic theory of matter is based was introduced by James Clerk Maxwell during the previous century. The models used in quantum-theoretical physics are also statistical models, and the assertions couched in terms of them are statistical assertions about the elementary particles. The models actually used for the study of matter in bulk—that is, of gases, liquids and solids treated as continuous media—can, in theory at least, be inferred as limiting or asymptotic forms of the statistical model proposed in the kinetic theory where matter is treated as an aggregate of discrete molecules. Thus the theory of probability lies at the foundations of modern physics. It plays no less important or indispensable a role in genetics, communication theory or game theory and quite generally is an essential component of a major part of analytical thinking about the biological, psychological and social behaviour of man.

The theory of probability and its statistical applications took their origins in the sixteenth century and were quite extensively developed by the end of the eighteenth. The two succeeding centuries saw this development carried very much farther ahead, on both the theoretical and the practical sides. As a branch of mathematics probability theory came to be identified as a part of general measure theory, and many of its central problems received beautiful solutions in this framework, particularly the ergodic theory of George D. Birkhoff (1884–1944) and John von Neumann which removed a puzzling difficulty at the heart of statistical mechanics and opened up interesting new avenues for technical progress in probability theory itself. The basic meaning of statistics for the study of all sorts of natural phenomena became very much better understood and appreciated than it was fifty years before, as the statistical models proved their effectiveness and versatility. Thus probability and statistics, if not at all new, certainly played a much more prominent and characteristic role during the twentieth century than they did in any of its three predecessors. The key to their success was that they made it possible to deal effectively with very large numbers of like objects at a time when the attention of scientists was shifting from individuals or small numbers of individuals to large aggregates of them.

An extremely practical development equally characteristic of the twentieth century was the invention and utilization of high-speed electronic computers. The dream of building powerful machines which could surpass the capabilities of human calculators was by no means a new one. In particular, Charles Babbage (1792–1871) during the nineteenth century had already conceived and worked on such a machine, introducing principles of design which continued to be of use in the computing art. The extraordinary development which took place in the twentieth century was stimulated by the rising demand for speedier and more versatile means for computing the solutions to problems in engineering and applied mathematics.

Modern computing devices were made possible by the conjunction of progress in two apparently unrelated directions, in electronics and in the formalization of mathematics and logic. While the machines developed in the 1950s were subject to various limitations, particularly as concerns their capacity for retaining or remembering data required in the course of an elaborate computation, they were exceedingly powerful and versatile. Their introduction therefore produced a marked alteration in the relations between mathematics and computing procedures. Since a machine of advanced design can handle at high speed almost any programme of successive elementary calculations which can be framed in logical terms, there was far less need than formerly for treating the computational aspects of a mathematical problem as an integral part of its discussion or solution in mathematical terms. These aspects became the direct concern of specialists in the writing of programmes for the machine. Such specialists needed to know both mathematics and the nature of their machines in order to choose the most economical ways for carrying out the computations desired in a wide variety of situations. They were engaged, therefore, in a task which has close contacts with logic as well as with algebra and analysis, and were beginning to build up a theory of computation which would eventually be ranged among the various branches of applied mathematics.

The capacity of the electronic computers was sufficiently great for them to be applied to furnish detailed information about areas which had hitherto been pretty much closed off because the necessary calculations were too massive to undertake and still not massive enough to be handled through asymptotic approximations. For instance, the treatment of management and decision problems leads to a mathematically rather simple model but one which in general contains too many variables for easy computation and too few for the application of asymptotic formulae. The theory of this model, known as linear programming, would therefore be of fairly restricted practical interest if it were not for the high-speed computer.

The modern machines offered new possibilities for the study of certain models for selected aspects of human behaviour. When for instance a description of what takes place in a social situation involving a group of individuals with assumed types of reaction can be formulated, the result can sometimes be converted into a mathematical model for the behaviour of the group and its implications calculated with the aid of a suitable machine. Since models of this kind often involve a number of variables in the range where direct computation had been the only way of getting at their mathematical properties, the machine was becoming an important research tool for the social scientist.

Thus, as these examples show, the improvement of computing devices and of skill in using them could be expected to give strong stimulation to the various branches, old and new, of applied mathematics. There were likewise possibilities for interesting uses of electronic computers in studying questions

in pure mathematics, particularly those where empirical evidence is needed before general theories can be formulated or those where it is necessary to treat a limited number of special cases left aside by a general discussion.

III. ADVANCES IN PURE MATHEMATICS

The advances which took place in pure mathematics itself from 1900 on can be explained only in technical terms, but certain salient features of the growth of mathematics in the twentieth century may nevertheless be noted. In trying to describe them there is no better way than to examine the different branches into which mathematics traditionally may be divided: algebra, number theory, geometry, analysis and logic. It is not possible to give an adequate picture of the rich and varied discoveries made since the beginning of the twentieth century in each of these separate branches; but a correct impression of the unprecedented level of activity reached by mathematics can perhaps be conveyed by a brief survey going beyond the mere mention of statistical facts such as the number of mathematicians primarily engaged in research—some 3500 in the late 1950s—or the volume of their publications, an idea of which can be gained by inspecting an abstracting journal such as *Mathematical Reviews*.

1. *Algebra*

Algebra probably had a more spectacular development than any of the other branches of mathematics, because it not only underwent an extensive internal transformation but also penetrated deeply into all the rest, with a notable unifying influence. Inasmuch as algebra deals with very general mathematical systems indeed—an algebra in the widest sense is simply a mathematical system in which the relations are finitary and functional, being expressible therefore in terms of abstract operations upon its abstract elements—it is by no means surprising that algebras should occur in all sorts of places and thus provide unifying bonds among the various branches and parts of mathematics. Internally algebra took the path toward abstraction and latterly gave an increasing amount of attention to systems beyond the traditional ones. Thus in addition to studying groups, rings, fields, vector systems and linear algebras, modern algebra was also concerned with general multiplicative systems (or systems with binary composition), various non-associative rings and algebras, lattices, and so on. A number of general theorems about algebras in the widest sense were established and may be thought of as constituting a kind of 'universal algebra'.

Algebra has always played an important part in geometry and in the twentieth century it extended and deepened its connections there. Indeed there are some portions of geometry—namely, algebraic geometry and combinatorial topology—which it more or less came to dominate. Whenever there is question of transformations or of operations on geometric entities, algebra

has a geometric role to play; the classical instances are the introduction of co-ordinates and the reduction of geometry to the study of transformation groups. As mathematicians took a broader and more abstract view of algebra they discovered more of such applications of algebra to geometry. On the other hand the formulation of geometrical problems in algebraic language presented algebra with new types of questions and led to new algebraic techniques and theories. A good example of the influence of geometry upon algebra is found in the case of homological algebra, which resulted from the development of certain techniques in combinatorial topology.

2. *Number theory*

Number theory has always been closely allied to algebra, providing it with many of its central problems. While many of these problems, be they concerned with the integers or with more general algebraic number systems, can be treated algebraically, some have also strong ties with analysis. Numerous problems of additive and multiplicative number theory have indeed been attacked by analytical methods with considerable success. One of the most concerted efforts along this line was made early in the twentieth century when Riemann's programme for studying the distribution of the prime numbers by means of the zeta-function was pushed extremely hard but with only partial success. Later there was a tendency to reduce the use of analysis to a minimum, often with much better success than might have been anticipated. Thus an 'elementary' proof of the prime number theorem, without use of the zeta-function, was carried through only in the 1940s. Some of the problems of number theory have connections with algebraic geometry which are extremely illuminating and which in certain cases have suggested the way to a solution. Such was the case for the multiplicative number theory of algebraic function fields and the study of the associated zeta-functions, where the analogue of Riemann's programme proved to be feasible. The history of number theory during the twentieth century records a whole series of brilliant contributions. Some solved old problems, some made significant advances short of complete success; but, as always in this difficult field, all bore the stamp of virtuosity.

3. *Geometry*

Geometry is a branch of mathematics which it is hard to characterize in a satisfactory way. On the one hand it has close ties with algebra, as has already been noted. On the other it has firm bonds with analysis. At times it almost appeared that geometry might be torn asunder, one part being absorbed by algebra, the other by analysis. Certainly, with the execution of the modern programme of treating algebraic geometry over a very general base field of co-ordinates, this part of geometry seemed to have been firmly appropriated by the algebraists. Differential geometry, however, is inseparable from analysis and the number of its problems requiring powerful analytical methods

for their solution seemed to be increasing. Of course, geometry unites operational and continuity considerations, and the split mentioned above results in part from an attempt to examine these separately. Just as the examination of strictly algebraic features resulted in the creation of the modern form of algebraic geometry, so the isolation of the continuity considerations initiated that part of geometry known as topology.

Topology is hardly a very recent arrival on the mathematical scene, as it goes back at least to Leonhard Euler's (1707–83) Königsberg bridge problem, but by far the greater portion of its development took place during the twentieth century. This development was perhaps the most intensive undergone by any branch of mathematics since 1900. Topology itself was pulled in two directions, because some parts of it can be put in algebraic terms and treated by algebraic methods. These parts were drawn closer to algebra, and the remaining parts, where the fundamental continuity properties have to be kept to the fore, were thus somewhat separated from the others. Even in differential geometry, where the use of real or complex co-ordinates makes the continuity properties an essential feature of the whole subject, there are important algebraic aspects. These enter either through the combinatorial topological properties of a differentiable manifold or through the use of tensor algebra to characterize the local linear structures over the manifold.

The development of geometry during the twentieth century was on the whole opportunistic and not very well co-ordinated. Advances pushed far ahead into new territory in certain directions while there was little or no progress in others. The problems which were of interest at the opening of the century were in many cases replaced by others and almost forgotten. There was more concern with foundational questions than with technical problems of the classical kind. At mid-century, with advances in algebra, topology and analysis providing the means for attacking hitherto refractory problems, geometry was beginning to make very substantial advances of a fundamental kind, and it seemed reasonable to expect a very brilliant period for geometry during the following years.

4. *Analysis*

In some ways the emergence of functional analysis may be considered to be the most characteristic technical feature of twentieth-century mathematics. Functional analysis is, for one thing, essentially a creation of this century; and it is, for another, the central meeting-place of algebra and topology. In fact if one looks at the basic structures studied in modern mathematics one sees three fundamental types—the algebraic systems as described above; the topological spaces or mathematical systems in which only continuity relations are given; and the partially ordered systems, not previously mentioned. Partially ordered systems are primitive and simple as there is only one relation of order given in them; and they have direct connections with algebra

through lattice theory and with topology through set-theory. When a system has simultaneously algebraic and topological or ordinal properties, coupled together in a reasonable way, it may be called a topological algebra (or more specifically, a topological group, topological field, topological vector space, and so on).

Such mixed systems became the prime objects of study in modern functional analysis. They arise frequently as abstractions from classical analysis, which is directly concerned with functions of a real or a complex variable and the standard analytical operations upon them. The experience from the 1920s onwards showed that it is very fruitful to focus attention on these abstractions, studying various kinds of topological algebras on their own merits and applying information obtained about them to the solution or clarification of more concrete problems of analysis. This point of view involved a shifting of attention from individual problems of function-theory to problems concerning aggregates of functions. Inasmuch as geometry also is concerned with the union of algebra and topology, the language of geometry is useful in describing many of the structures met in topological algebra and, when used in connection with topics of analysis, often presents the latter under a helpful geometrical aspect. The theory of Hilbert spaces, Banach spaces and their generalizations, and the theory of linear operators on such spaces became central in modern functional analysis and provide illustrations of the importance of this kind of abstraction for mathematical progress. The theory of topological groups, which received special attention because of its significance for quantum theory, can be considered as a part of functional analysis, as it is concerned in fact with a generalization of harmonic analysis from the case of the additive group of the real numbers to the general case of a group with continuity properties. One of the signal achievements of twentieth-century mathematics was the solution of the fifth problem of a celebrated series proposed by David Hilbert in 1900, showing that under suitable restrictions upon a topological group it can be co-ordinatized as a group of analytical transformations of an analytical manifold into itself.

A part of analysis which is especially close to the traditional core of the subject and also to its applications, and which was nevertheless strongly influenced by modern functional analysis, is the theory of partial differential equations. One can perhaps gain a better appreciation of the significance and power of the new ideas in analysis by seeing what they can accomplish in a difficult classical domain than by looking at their success with newly formulated problems. At any rate it is a noteworthy fact that by the mid-twentieth century modern functional analysis had been throwing a rather bright light upon the theory of partial differential equations for some thirty years and was probably the most effective single factor in the steady advances made in that theory. Even in the case of linear equations with constant coefficients, where knowledge was still hardly more than rudimentary, progress had been made in recent years only with the aid of the theory of distributions and

would have been impossible otherwise. Thus the modern approach in this important area of mathematics more than justified itself by its successes with old problems as well as new.

5. *Logic*

To give an accurate account of recent technical advances and discoveries in symbolic or mathematical logic would require a patient examination of subtleties best appreciated against a broad mathematical background. Stimulated by Hilbert's bold proposal to establish the adequacy and freedom from contradiction of at least one fairly substantial portion of mathematics as formalized within a suitable symbolic logical system, logicians began to look more closely at the structural features of certain versions of the so-called 'first-order predicate calculus' and corresponding formalizations of set-theory and arithmetic. In the 1930s Kurt Gödel made the astonishing and extremely disconcerting discovery that for a wide variety of formal systems—in particular, for one combining the first-order predicate calculus with a formalized arithmetic—adequacy and freedom from contradiction are incompatible. More precisely, he showed that there are propositions of formal arithmetic which cannot be proved or disproved—in other words, which are undecidable—by means of the formal apparatus of the first-order predicate calculus as applied to the formal axioms given for arithmetic so long as the system is consistent, but that this is not due to any inadequacy of the first-order predicate calculus taken by itself. A related but independent result was Alonzo Church's (1903–) discovery that no systematic procedure can be prescribed for deciding which formal statements or sentences in first-order predicate logic are provable. Independently, A. M. Turing (1912–54) presented this result in a more picturesque form by showing that none of a wide class of 'machines' which he described could furnish such a decision.

Thus logic suddenly burgeoned with these and other paradoxes of an extremely subtle nature, difficult to comprehend and impossible to ignore. The mechanism which produces such paradoxes came to be much better understood, and the paradoxes therefore seemed rather less astonishing than they originally did. Their challenge was not one whit less for all that. Most of the paradoxes invite philosophical discussion, but those due to Church and Turing also have a bearing on another aspect of formal logic. This is because the latter raise the question as to whether or not the brain is a mechanism subject to the limitations explicitly established by Turing for his machines. It did not seem likely that any of these problems would be soon resolved by purely technical means, or even by anything short of new and highly original insights. In the meantime logicians and mathematicians were busy with other problems of a more technical nature and less philosophical interest, refining and enlarging concepts of logic as a formal discipline.

IV. EXPOSITION AND TEACHING OF MODERN MATHEMATICS

The rapid growth of mathematics during the twentieth century, and the accompanying extensive alterations in its general nature and its technical content, made it vitally necessary for mathematicians to concern themselves in an active way with the exposition and teaching of modern mathematics. At the level of exposition there was a growing need for presentations of the new subject-matter of mathematics and its organization into systematically arranged and perceptively correlated chapters. The most ambitious attempt to provide such a presentation, with every detail of definition, notation and demonstration carefully worked out, was that made by a number of French mathematicians banded together in the name of Bourbaki. Beginning in the 1930s this group worked steadily, with some changes of membership, to prepare a general statement of modern mathematics in the form of an encyclopaedic treatise. After twenty years of work they were, naturally enough, still far from their goal and were forced to undertake a revision of the volumes they had already published. A considerable part of what was written in the treatise of Bourbaki dealt with set-theory, general topology, algebra and linear functional analysis—precisely the topics which were being developed to an unusual degree and which therefore presented the greatest problems for an expositor.

The new mathematics also created need for a thorough reform in mathematical instruction at all levels, to the end that elementary mathematics in the schools might be thoroughly modernized, better articulated and better adapted to the requirements of youth in a technological civilization. A very considerable portion of the mathematics taught at the advanced university level in the 1950s was not taught at all thirty or forty years before. As a result it became necessary to compress and condense the mathematics taught in schools and in the earlier university years as preparation for advanced instruction in the modern spirit. In consequence there developed an increasingly disturbing gap between school mathematics and university mathematics in many parts of the world, one symptom of the grave crisis which was overtaking education in the new scientific age. In the debates, the experiments and the organized efforts stimulated by this profound crisis in education, mathematics was at the very centre of the struggle to make the scientific knowledge of the times more accessible to the common man and to increase its cultural and technological role in the interests of mankind as a whole. In view of the nature of mathematics and its potentialities for the future of science, this could not be otherwise as mathematics entered the second half of the twentieth century.

SECTION TWO

THE ELABORATION AND APPLICATION OF THE PHYSICAL SCIENCES

CHAPTER VIII

THE ELABORATION OF THE PHYSICAL SCIENCES*[1]

I. INTRODUCTION

THE rapid increase of scientific and technical knowledge brought a concomitant increase in specialization as it became necessary for a single individual to master a great wealth of detailed knowledge in order to keep abreast of even a narrow field of inquiry. It became a cliché to contrast the 'narrow specialist' of the twentieth century with the 'universal genius' of the past. However, concurrent with this trend toward specialization there was a unifying trend. Whereas in former times one man might be able to strive at the frontiers of knowledge in several fields such as physics, chemistry and geology, there was little unity in the subject-matter in these areas of knowledge. Physics and chemistry appeared to be separate and well-defined disciplines. In general, geologists rejected the notion that the rocks they studied were amenable to understanding by the laws of chemistry and physics. Application of physics to astronomy was limited to celestial mechanics in which Newton's laws of motion were used to predict the movement of astronomical objects.

In the twentieth century the isolation of the various physical sciences was disappearing as a consequence of the development of a universal theory of matter. The knowledge of the properties of atoms and molecules gained by the nineteenth-century chemists and the mechanical laws and electromagnetic theory of the physicists were extended and unified by new discoveries, particularly by the discovery of the existence and properties of the elementary particles, especially the electron, proton and neutron, and by the development of quantum mechanics. As a result of this unification the boundaries between physics and chemistry became much more arbitrary, being drawn at least as much by tradition and historical accident as by any inherent difference in the subject-matter.

Physical science in the middle of the twentieth century, whether pursued in the name of physics, chemistry or some other science, largely consisted of extending still further the theory of matter and applying it to all imaginable portions of the physical world. A unified theory of matter was being applied with equal confidence to increase man's understanding of the properties of familiar metals, of the material in the core of the earth and of the most distant regions of the universe. Much of biology was being approached as a

* This chapter was prepared by Dr. George W. Wetherill.

physical science, and there were few astronomers who did not refer to themselves as astrophysicists. The development of the new theory of matter was the central development of twentieth-century physics and chemistry and the new understanding of the structure of matter which it provided transformed the disciplines of geology and astronomy.

In addition to its success in integrating the physical sciences, this new development had incalculable importance to technology. Whole industries developed as a consequence of man's increased understanding of the nature of matter. Basic discoveries were frequently translated into commercial products within a few years, while on the other hand the products of the most highly advanced technology provided the tools without which much of the basic research would be impossible.

II. THE NATURE OF MATTER

1. *The heritage of classical physics and chemistry*

By the end of the nineteenth century a great and satisfying synthesis of macroscopic phenomena had been achieved. To the classical work on mechanics of the seventeenth and eighteenth centuries had been added a new understanding of thermodynamics and electromagnetic phenomena, the latter principally as a consequence of the experimental work of Michael Faraday and the theoretical contributions of James Clerk Maxwell. Maxwell had succeeded in unifying in a few simple equations such diverse phenomena as the attraction of oppositely charged bodies, the rotation of electric motors and the reflection of light. The three fields, mechanics, electromagnetism and thermodynamics, had been integrated by the far-reaching principle of the conservation of energy.

Yet even within this grand system some inconsistencies remained until Einstein's Special Theory of Relativity in 1905 provided a key to the principal unsolved problems. The delicate experiments by Michelson and Morley* had failed to detect any motion of the earth with respect to the hypothetical aether, whereas the classical theory of light led scientists to expect such a motion. Einstein showed that it was possible to write the laws of mechanics and electromagnetic theory in such a way that they would be identical in all systems of co-ordinates moving at constant velocity with respect to one another. In this theory the velocity of light is the same in any of these co-ordinate systems, thus explaining the negative result of the Michelson–Morley experiment.

To accomplish this result Einstein altered slightly the classical equations of mechanics, together with the equations used to convert data measured in one co-ordinate system to its equivalent in a relatively-moving co-ordinate system. These changes in the laws of mechanics were so slight that the discrepancies which they corrected had been undetected in the previous experimental data.

* *Supra*, p. 131

However, many experiments were subsequently designed and performed to test the predictions of the Special Theory of Relativity and the theory was strikingly confirmed. Thus, early in the twentieth century the Special Theory of Relativity completed the grand synthesis of macroscopic physics and formed the capstone to this monument of nineteenth-century thought.

Looking back at nineteenth-century physics from the mid-twentieth century it appeared that much of the completeness of this synthesis arose from the choice of phenomena of interest to the physicist. There were vast classes of physical phenomena which the classical physics could never explain. For example, when an electrical discharge is passed through hydrogen the light emitted by the gas is confined to certain discrete wavelengths, referred to as spectral lines. This set of wavelengths forms the characteristic spectrum of hydrogen which is different from the equally characteristic spectrum of any other element, say, nitrogen. These spectra were an important practical tool in physics, chemistry and astronomy. Classical models of an atom were constructed in an attempt to explain these spectra, but classical physics proved unable to say just why a given element was capable of emitting certain wavelengths and not others.

Another example can be drawn from the theory of elasticity which was greatly developed during the nineteenth century. This theory is founded on the assumption known as Hooke's law, which states that when a body is deformed the deformation is proportional to the force causing the deformation, or as more commonly expressed, the strain is proportional to the stress. The factor of proportionality between the strain and the stress is called the elastic constant and will in general depend on the type of deformation. Thus the elastic constant for deformation by twisting is generally different from that for deformation by stretching.

Early in the nineteenth century there was a serious controversy among various leading physicists and mathematicians who were engaged in developing a theory of elasticity as to how many different constants it was necessary to specify in order to describe the elastic properties of a body. One school held that two were necessary, one to describe the resistance of the body to stretching and the other its resistance to twisting. The other school maintained that only one constant was necessary and if this one were given the other could be calculated. The fundamental difference between the theories proposed was that the one-constant school made certain assumptions about the forces between the atoms and molecules of which the body was composed, whereas the other did not.

While there were always advocates of the one-constant view, it was characteristic of nineteenth-century physics that the main stream of progress in the classical theory of elasticity followed the two-constant view and the great successes made by this theory by the end of the century were accomplished by two-constant theories. The reason for this was that in the nineteenth century any theory which depended on the assumed atomic structure of a

body was doomed to failure because an adequate theory of atoms and their interactions simply did not exist. The two-constant theory depended only on more general principles such as the laws of mechanics and thermodynamics which were well established by the middle of the nineteenth century. However, as a result of the new understanding of the structure of matter it became feasible actually to undertake the calculation of the elastic constants from more fundamental principles, and even to understand the circumstances under which Hooke's law will fail to be valid.

As illustrated by these examples, scientists of the last century made repeated efforts to explain phenomena which depended on the microscopic structure of matter. These attempts were seldom successful except in a few cases such as the classical kinetic theory of gases. However, the successes of classical physics in the macroscopic realm were so great that these difficulties were not taken very seriously and the state of the science was generally regarded as being eminently satisfactory.

Nineteenth-century chemistry, too, had constructed a comprehensive system of chemical elements and their interrelationships which was regarded as complete, though it rested on empirical observations whose rationale was unexplained. The early work along lines laid down by Antoine Laurent Lavoisier (1743–94) in the late eighteenth century had identified many chemical elements, studied the simpler reactions between them, and had established that elements, to a very good approximation, combine in weights proportional to small whole numbers. At the beginning of the nineteenth century John Dalton (1766–1844) had conceived that this law of multiple proportions could be explained if a given chemical element was composed of identical, indestructible atoms of matter of a definite weight, and with this theory he had laid the foundations for the subsequent development of chemistry.[2]

The atomic theory had led to the development of precise techniques for the determination of atomic weights and many of the analytic procedures which continued in use had their origin in this work. It also provided an interpretation of the concept of valence. The valence of an element represents the relative proportions in which hydrogen combines with a given element. For example, one atomic weight (one gram) of hydrogen reacts with one atomic weight (35.5 g.) of chlorine to form hydrochloric acid whereas in the analogous reaction with oxygen two atomic weights of hydrogen are required to react with one atomic weight (16 g.) of oxygen. Therefore chlorine is said to have a valence of one while oxygen has a valence of two. In terms of the atomic theory the oxygen atom is thought of as being able to link with two hydrogen atoms whereas the chlorine atom links with only one. This property of valence, like atomic weight, is a fundamental property of an element and therefore, in accordance with the atomic theory, must represent some property of the atoms of that element.

In 1869 Dmitri Ivanovich Mendeleyev (1834–1907) had succeeded in

connecting the atomic weight, valences and many other properties of the elements by his famous periodic system which showed how the properties of the elements tend to be repeated when arranged in order of increasing atomic weight. On the basis of this discovery it was possible to predict the existence and properties of a number of missing elements, some of which were quickly discovered.

There had also been a great development of organic chemistry following the successful synthesis of urea from inorganic matter by Friedrich Wöhler (1800–82) at Göttingen in 1828, which had disproved the idea that there was a fundamental difference between organic and inorganic matter. Many new compounds had been synthesized, their reactions understood and the structural form of their molecules established.

In the field of physical chemistry the laws of thermodynamics had been applied to the problem of chemical equilibrium leading to the formulation of the law of mass action; the techniques of electrochemistry had been established and the groundwork was laid for a theory of the rate of chemical reactions.

Great as these achievements were, the underlying foundations of nineteenth-century chemistry were largely empirical. There was no reason known why atoms should unite themselves into molecules in some ways and not in others. Studies of the ionic salts such as sodium chloride suggested that the binding was electrical in nature, but on the other hand there was the vast number of compounds of carbon in which the binding did not seem to be electrical. There was no reason known why the properties of the elements should repeat themselves as shown by Mendeleyev nor why some compounds such as water were liquid under ordinary conditions whereas others such as methane were gaseous. The whole field was badly in need of a generalization to replace the rapidly growing collection of empirical facts. As the result of the combined efforts of physicists and chemists the development of the theory of the nuclear atom and the laws of quantum mechanics during the twentieth century provided this generalization.

2. *The development of the new theory of matter*

(*a*) *The nuclear atom model.* It has commonly happened in the development of science that great new discoveries do not follow naturally from questions logically raised as consequences of earlier work. In some cases they seem to stem more from technological advances which permit new types of measurements to be made. The discoveries which led to the breakdown of classical physics and opened the way to the explosive development of atomic physics in the twentieth century can be traced to the invention of a greatly improved vacuum pump by Heinrich Geissler (1814–79) in 1855, and further improved by other workers. While these pumps were very slow and inefficient by modern standards, they were so great an improvement over earlier ones that many scientists were encouraged to make experiments on gases at low

pressures. In particular they studied the electrical properties of such gases and discovered many new phenomena such as the bright discharges familiar in neon signs and beams of particles which they named cathode rays. J. J. Thomson, working at the Cavendish Laboratory in Cambridge, England, showed that these cathode rays were the same regardless of the material which produced them, and formed the conclusion that they were atoms of electricity or electrons.

Using similar cathode-ray tubes Konrad von Röntgen in 1895 discovered a new type of radiation which could penetrate opaque material and which he named X-rays. It was suspected at the time that these rays were related to the fluorescence produced in the glass wall of the apparatus by the bombardment of the cathode rays. X-rays had immediate medical application, but perhaps even more important for the development of science was the fact that their discovery stimulated the French scientist Henri Becquerel to conduct a series of experiments on fluorescence, using naturally fluorescent minerals containing the element uranium. These experiments led to the discovery of natural radioactivity in 1896.

Naturally radioactive elements were found to emit three distinct kinds of energetic radiations in processes by which these unstable heavy atoms spontaneously transmute from one chemical element to another; the three types of radiation were called alpha, beta and gamma before their real nature was known. As a consequence the naturally radioactive materials proved to be extremely valuable as sources of high-energy particles which could be used in other studies of the nature of matter. Further study showed that the alpha radiation consists of a stream of relatively heavy, positively charged particles known to be high-speed nuclei of helium atoms. The beta radiation consists of a stream of much lighter, negatively charged particles, of the same nature as the electrons of cathode rays except that they possess much more energy of motion than any cathode rays which could be made with the technical means available at that time. Finally, the gamma radiation was found to be like electromagnetic radiation X-rays, but of even shorter wavelength.

The most decisive experiments in this field were those made by Ernest R. Rutherford in Manchester, England. He studied (1911) the angular scattering of high-speed alpha particles as they went through thin foils of various materials. His work showed, in the cases where the particles were deflected through moderately large angles (10 degrees or more), that the deviation was the consequence of a strong interaction of an alpha particle with a single atom of the scattering foil, not the cumulative effect of weaker interactions with many atoms in the foil. From quantitative study of such angular scatterings, especially at large angles, Rutherford inferred that the positive electricity in the atom was not spread out through the whole atom of diameter about 10^{-8} cm, but would have to be concentrated on a small nucleus which could not have more than ten-thousandth the diameter of the whole atom. Moreover, by comparing the way in which various elements scattered alpha particles he

found the relative amounts of positive charge in the nucleus of different elements.

In this way was born the concept of the nuclear atom, i.e. that atoms consist of a small centre of positive charge about 10^{-12} cm. in diameter surrounded by an equal negative charge in the form of electrons at a distance of about 10^{-8} cm. The positive charge on the nucleus was thought of as arising from a number of positive atoms of electricity called protons, analogous to the negative electrons. This concept thereafter formed the basis of all understanding of matter. In the normal state each nucleus is surrounded by enough negatively charged electrons to make the atom as a whole electrically neutral. All the atoms of a given chemical element resemble each other in having the same nuclear charge, and hence the same number of electrons moving around outside the nucleus. This number is called the atomic number, usually denoted by Z.[3] Thus the chemical elements stand in one-to-one correspondence with the integers, from one for hydrogen through 2 for helium, 3 for lithium, 4 for beryllium, 5 for boron, 6 for carbon, 7 for nitrogen, 8 for oxygen, on up to 92 for uranium, the largest value of Z for a naturally-occurring chemical element.

About this same time J. J. Thomson devised an instrument called a mass spectrograph by means of which the relative masses of individual atoms could be determined. With this instrument it was soon learned (1910) that not all atoms of the same chemical element are alike in mass. Thus the atoms of neon ($Z=10$) are found to be of three kinds, with masses $A=20$, 21 and 22 on a scale of which ordinary hydrogen has a mass number $A=1$ and ordinary oxygen has $A=16$. Such different kinds of atoms of the same chemical element are called isotopes. In terms of Rutherford's nuclear model these experiments showed that nuclei can have a range of masses for a given positive charge Z.

Hardly had Rutherford made his basic discovery of the need for a nuclear model than this idea was taken up and pursued with extraordinary fruitfulness by Niels Bohr. He was then a young Danish theoretical physicist who had recently gone to Manchester to continue his graduate studies. Bohr undertook to develop Rutherford's nuclear atom model by learning more in detail of the behaviour of the outer electrons and how this behaviour was related to the emission or absorption of light by a gas made up of many such atoms. In order to do this he had to make some drastic departures from what then seemed fully-established consequences of the known laws of electromagnetism. According to what was then known, the electrons ought to move around the nucleus in orbits. Being accelerated as they move, they ought to radiate electric waves, like the oscillating charges which generate radio waves. As they radiate they would lose energy and move faster in smaller orbits, and thus the frequency of the emitted light would steadily increase. Thus a gas of many such atoms ought to emit a continuous spectrum of frequencies, in sharp contradiction to the discrete sharp-line spectrum that is actually emitted.

To overcome this difficulty Bohr postulated that the atoms can only exist in sharply-defined discrete energy levels, implying that the electron orbits could have only definite sizes and shapes. He next postulated that an atom emits a unit or quantum of light radiation by making an abrupt transition or jump from a higher to a lower energy level, and absorbs radiation by an analogous transition from a lower to a higher energy level. Finally, he supposed that the frequency of the light emitted or absorbed in such jumps is equal to the difference in energy of the initial and final levels divided by Planck's quantum constant, $h = 6.55 \times 10^{-27}$ erg-sec.

With these simple but daringly radical postulates he was able to give a direct quantitative interpretation of the spectrum of atomic hydrogen. His work was quickly taken up by others, who proceeded to show how its natural extension could explain many detailed features of more complex atomic spectra.

A great fever of excitement was let loose in the world of physics by one success after another of the Rutherford–Bohr atom model. Soon the model was extended to give an account of the rotation and vibration spectra of diatomic molecules which were thereby interpreted to give quantitative data about chemical bonds between the atoms in such molecules. As illustrated by this latter development, during the next two decades physics and chemistry were rapidly joining to form one science with common fundamental laws which were becoming increasingly well understood.

(*b*) *The development of quantum mechanics.* Although Bohr's use of quantum jumps to interpret emission and absorption of light by atoms or molecules was radical by the standards of nineteenth-century physics, this assumption was a natural next step since the original idea of the light quantum had already been introduced by Max Planck in 1900. Planck was led to the idea by theoretical analysis of the radiation emitted by hot bodies. Because of its radical nature and the difficulty of the reasoning involved, the light quantum idea did not have much influence on physics until Einstein used it in simpler ways in 1905.

Since early in the nineteenth century light had been regarded as a wave motion. By the end of that century these waves were known to be waves of electric and magnetic force, and the mathematical laws governing their propagation were well understood. According to the light quantum idea as used by Bohr and Planck it is supposed that the energy exchange occurring when atoms emit or absorb light is discontinuous, in such a way that in a single elementary process energy is always emitted or absorbed in units which are always the same for light of a definite frequency, being in fact equal to $E = h\gamma$ where E is the quantum of energy, γ is the frequency of light and h, Planck's constant, is a universal constant whose value has to be determined from analysis of the observed phenomena.

In 1905 Einstein also used this idea to explain some puzzling phenomena observed in the photoelectric effect. This effect, which became familiar in

electric eyes for opening doors in stores or garages and in the television camera, consists of the observation that when light falls on a metal electrode electrons are emitted from the metal. Thus it seems that the beam of light is able to knock out electrons from the metal. However, it was observed that when the intensity, and thereby the energy, of the beam of light is increased the energy of the emitted electron does not increase but remains the same. The number of electrons emitted increases but it was expected from the wave theory that, since the energy of the incident light beam is greater, the light should be capable of knocking out electrons with greater energy, and therefore their energy should also increase.

The experimental result, puzzling according to the wave theory, becomes clear from the point of view that light is absorbed in quanta, the energy of one quantum being directly given to one electron. In this way Einstein showed how the photoelectric effect gives evidence of absorption of light in quanta, pointing the way to the incorporation of the same principle in Bohr's theory of emission and absorption of light by atoms.

According to Einstein's Special Theory of Relativity, any particle having energy, as does the light quantum, ought also to be the carrier of a definite amount of momentum. This conclusion gained experimental support in the studies in 1923 by Arthur H. Compton (1892–) on X-ray scattering, leading to the discovery of what came to be called the Compton effect. Thereby the reality of the light quantum became even more definitely accepted by physicists.

Although Bohr's ideas had great success and gave an immense stimulus to the study of atomic and molecular spectra, the exact detailed calculation of the energy levels of atoms other than hydrogen raised a number of difficulties. By 1920 many features of the complex spectra of many-electron atoms had been analysed, but there were puzzling details even about the structure of the relatively simple spectrum of sodium and the other alkali metals, and also about the behaviour of spectra when the emitting atoms are in a magnetic field (Zeeman effect). In 1925 it was found possible to patch up the Bohr theory by assuming that the electron is more complicated than being just a charged particle and that it is also endowed with a fixed amount of angular momentum, like a spinning top, and a magnetic moment, like a tiny bar magnet. These properties, called electron spin, became a firmly established central part of all atomic theory.

In the decade following Bohr's first paper on his atom model in 1913 no one did more than Bohr to keep the attention of scientists focused on the fact that its principles were far from complete or satisfactory. That electrons in atoms do not behave like particles obeying Newton's laws of motion was evident, and some partial rules about the nature of the departure from them were known. It was clear that classical mechanics needed to be replaced by a new quantum mechanics which would agree with classical mechanics when applied to large systems and give differing but correct results when applied to

atomic systems. To discover the laws of quantum mechanics was the crucial problem of theoretical physics in the early 1920s.

The answer to this problem came from two directions, not at first recognized as providing the same answer. Louis de Broglie (1892–) published (1924) a paper in which he suggested that since light seems to have a dual nature, in some ways appearing to be a wave and in other ways a particle, this duality might also apply to electrons and protons, and that these particles might also have wave properties. Erwin Schrödinger (1887–) of Zürich took up the idea two years later and put it in a more definite mathematical form, discovering the equations of quantum mechanics in a form called wave mechanics. These equations formed the basis of the methods of treating atomic systems thereafter.

The other approach to the subject was initiated in 1925 by Werner Heisenberg and led to a formulation of quantum mechanics in which physical quantities were represented by a kind of mathematical quantity called a matrix. Matrix algebra was at that time quite unfamiliar to most theoretical physicists, a fact which, when combined with the physical novelty of the new concepts, made for great difficulty in their assimilation.

By 1927 the new methods, wave mechanics as developed by de Broglie and Schrödinger and matrix mechanics as developed by Heisenberg, were recognized to be the same theory in two different mathematical cloaks.

Experimentally the new ideas gained quick support through the discovery in 1927 of electron diffraction. It was shown that electrons when scattered by a crystal behave as if their motion were governed by the associated wave motion postulated first by Louis de Broglie, and they are diffracted much as light waves are diffracted by a diffraction grating.

The new ideas introduced a complete break with the ideas of classical mechanics. In the theory which originated with Newton, motion was fully determined by the initial positions and velocities of the moving parts and the forces acting on them. However, it was now seen that at the atomic level the motions were undetermined and that the wave function of Schrödinger serves to indicate only probabilities or relative likelihoods of the various possible motions.[4, 5] In 1927 Heisenberg completed the recognition of the essential nature of the indeterminate elements of the quantum theory by showing that they had their origin in the impossibility of making certain measurements of infinitely great precision.

These new ideas proved to be extraordinarily fruitful in the following thirty years. To a new generation of physicists and chemists they seemed perfectly natural. But at first the implications of uncertainty were resisted vigorously by many theoretical physicists. Thus Albert Einstein, while recognizing the many successes of the mathematical formalism of quantum mechanics, refused during the remainder of his life to believe that the indeterminacy aspects represent a fundamental and final limitation of knowledge. Instead he believed that these ideas represent only a temporary lacuna in our

understanding which he expected would somehow be filled in by future discoveries.

The first main consequence of the discovery of the mathematical laws of quantum mechanics was that it permitted a highly detailed completion of the theory of atomic spectra and opened also the way to a greater understanding of the nature of the chemical bond between atoms in molecules. The simplest type of molecule is the hydrogen molecule, formed by the bonding together of two hydrogen atoms. Each hydrogen atom has a nucleus consisting of a single proton to which is bound a single electron. Until the advent of quantum mechanics there was no known reason why these hydrogen atoms should join to form a hydrogen molecule.

In 1927 Walter Heinrich Heitler (1904-) and Fritz London (1900–54) in Zürich showed that an attraction between these two atoms should arise in a way that is peculiar to quantum mechanics and has no counterpart in classical physics. These exchange forces provide not only a quantitative understanding of binding in the hydrogen molecule but give a qualitative picture of the nature of chemical bonds in other more complex molecules and also an understanding of the reasons for chemical valence.[6] The new theory also gave a clear understanding of the fundamental structural distinction between solids that are insulators and solids that conduct electricity.

The new theory clarified the fundamental basis for the periodic system of the elements. The regularities exhibited in the periodic system obviously reflect some more fundamental underlying principle. In 1924 Bohr attempted to explain the periodic system in terms of his atom model but although he was certainly on the right track the ambiguities inherent in his theory made a definitive explanation impossible. During the next few years, the discovery of electron spin, the exclusion principle and the quantum mechanics of Schrödinger and Heisenberg permitted the resolution of these ambiguities.

According to these new ideas the simplest atom is that of hydrogen with one electron bound to the nucleus. This electron will be, in its lowest energy state, characterized by the quantum number $n = 1$. In the next heavier atom, that of helium, there is an additional electron having this same quantum number, but this second electron will be spinning in the direction opposite to that of the first. According to the exclusion principle proposed by Wolfgang Pauli (1900–58) in 1925, no more electrons can be added with $n = 1$, and this shell is said to be closed[7]. The other inert gases—neon, argon, krypton, xenon—share this property of having their last electron shell closed. In the next heaviest atom, lithium, the third electron must be in the next shell, characterized by the quantum number $n = 2$. The alkali metals—lithium, sodium, potassium, rubidium, caesium, and francium—share this property of having one electron in the next higher shell above the closed shell characteristic of the inert gases. It is this similarity in the configuration of the outermost electrons which produces the similarity in the chemical properties of these groups of elements, since the outermost electrons are the most effective

in the interactions leading to chemical reactions. The exclusion principle, together with the equations of quantum mechanics, show that this second shell, $n = 2$, can hold eight electrons. When this second shell is closed the total number of electrons is $2 + 8 = 10$. The element with an atomic number of 10 is neon, the second insert gas. The next element is the alkali metal sodium with one electron in the shell $n = 3$. Continuation of this reasoning led to an understanding of the reason why all the other groups of elements such as the alkaline earth's and the rare earths had similar chemical properties.

The links between chemistry and physics which were forged by the Bohr theory were strengthened by the development of quantum mechanics. In the next decade great strides were made in fundamental chemistry as numerous investigators took advantage of the sudden increase in understanding made possible by the new theory. Modern theoretical chemistry as well as solid-state physics largely consists of a continuing exploitation of this theory.

(*c*) *The early development of nuclear physics.* The developments in physics and chemistry initiated by the Bohr theory and crowned with the successes of quantum mechanics form the subject known as atomic theory which deals with aspects of the atom outside the nucleus but in which the internal structure of the nucleus itself is not considered. At the time of the great success of atomic physics and chemistry in the late 1920s little had been done to extend the pioneer work of Rutherford in the study of the nucleus itself. As early as 1919 Rutherford had succeeded in transforming one type of nucleus into another. He bombarded nitrogen gas with alpha particles and found that high-energy protons were emitted indicating that an alpha particle enters a nitrogen nucleus for which $A = 14$ and $Z = 7$ and knocks out a proton, leaving an isotope of oxygen of mass 17. However, the total yield of such particles was extremely small so that further effective work on nuclear reactions had to await the development of large electrical devices which are able to accelerate large numbers of protons and alpha particles up to energies of several million electron volts.

In the excitement of working out the consequences of the new discoveries in atomic physics during the 1920s the physics of the nucleus was largely neglected. But when atomic theory seemed to be well established around 1930, many physicists returned to the study of the nucleus and to the development of the necessary accelerating devices.

The production of a nuclear reaction with artificially accelerated particles was first achieved in 1932 by John Douglas Cockcroft (1897–) and E. T. S. Walton (1903–) at the Cavendish Laboratory, Cambridge, England. After that the study of nuclear reactions was carried out on a large scale in many laboratories with the aid of particles accelerated in the cyclotron as first built by E. O. Lawrence (1901–58) in California in 1931 and in the electrostatic belt machines of the type introduced about the same time by R. J. Van de Graaf (1901–) in Princeton, USA.

In other ways the year 1932 was an important one in the development of

nuclear physics. In that year James Chadwick discovered the existence of a third kind of fundamental particle, having no electric charge and a mass nearly the same as that of the proton. Because of its electrical neutrality he named this particle the neutron. It was quickly pointed out that many difficulties could be accounted for by supposing the atomic nucleus to consist of both protons and neutrons. In the following quarter-century this view of the constitution of the nucleus was so overwhelmingly successful as to leave no doubt of its correctness. Although subsequently other kinds of fundamental particles were discovered it remained true that all ordinary matter consists of only the three kinds of particles: protons, neutrons and electrons. Thus the various chemical elements are characterized by having a nucleus containing Z protons and K neutrons. The mass number A equals $K + Z$. Around this nucleus is a cloud of electric charge containing Z electrons.

Also during this same year a heavy isotope of hydrogen, deuterium, was discovered by H. C. Urey (1893–) at Columbia University, USA, and a new kind of particle, the positron, by Carl D. Anderson (1905–) in California.

The discovery of deuterium or heavy hydrogen was particularly important for nuclear physics in that its nucleus, called the deuteron, consists of but one neutron and one proton and therefore must have the simplest possible nuclear structure: a simple bond between a proton and a neutron. Deuterons can be accelerated to high energies in cyclotrons and other accelerators and used to produce nuclear reactions when they bombard targets of various elements. Writing d for deuteron, n for neutron, p for proton, α for alpha particle, we can distinguish (d,n), (d,p) and (d,α) reactions in which the deuteron enters the target nucleus and respectively a neutron or a proton or an alpha particle is emitted. Within a few years after 1932 many such nuclear reactions had been studied in considerable detail.

The discovery of the positron was important because it was the first of the elementary particles of transient existence to be discovered, and because it provided a confirmation of some peculiar predictions growing out of Paul A. M. Dirac's (1902–) theory (1928) in which the quantum mechanics of a single electron was put in a form consistent with Einstein's Special Theory of Relativity. Dirac's theory led to the conclusion that for each kind of elementary particle (one that is not structurally built of other particles) there should exist a related anti-particle, which would be its opposite in various ways. For the electron the anti-particle is the positron, a particle having the same mass as the electron and the same numerical value of electric charge, but the positive kind instead of the negative.

According to Dirac's theory a positron and an electron can mutually annihilate each other upon colliding, and in their place two quanta of gamma radiation are produced. Since there are so many electrons present in ordinary matter, a positron, somehow made, can have only an extremely transient existence before being annihilated in an encounter with one of the many electrons in its environment. For this reason positrons cannot play any role in

the structure of matter under ordinary conditions. The positrons that were discovered by Anderson are generated as a result of bombardment of the earth's upper atmosphere by high-energy cosmic rays and are found to suffer the kind of annihilation processes predicted by the Dirac theory. This discovery served as a great stimulus to more intensive studies of cosmic radiation and high-energy particle physics, which became a branch of physics of immense importance in the 1940s and 1950s.

By the late 1930s progress in the understanding of nuclear matter and in the elementary particles of nature occurred so rapidly and on so many fronts that it is exceedingly difficult to present a complete or even a one-dimensional narration of these important events. One of the major problems of nuclear theory was the understanding of radioactivity. The mechanism by which alpha particles are emitted quickly received a simple explanation in terms of the new quantum theory, but the nature of the process by which beta particles (high-energy electrons) are ejected from beta-active atoms remained a great mystery until 1934, when Enrico Fermi (1901–54) published the theoretical treatment which formed the basis of all subsequent work on the subject. The problem of beta-emission is different from that of alpha-emission in two respects. On the one hand there are sound theoretical reasons for believing that atomic nuclei do not contain any electrons. Hence one part of the emission process must involve the creation of the to-be-emitted electron out of some of the charge and energy (= mass) that is already present in the nucleus. While physicists already had some ideas concerning creation and destruction of particles from the Dirac theory and its confirmation in Anderson's positron discovery, such ideas were new and unfamiliar in the early 1930s.

The other major mystery in this field was the continuous-energy spectrum of the emitted electrons. The experimental evidence indicated that all the beta-active nuclei of a certain kind are alike both before emission and after emission. Therefore a certain definite amount of energy would be available for the emission; so all of the emitted electrons ought (by the principle of conservation of energy) to come out with the same energy. But instead, experimental work showed that actually they come out with a wide statistical distribution of different energies, ranging from a maximum value down to as near zero as can be found in view of the experimental difficulties.

The solution to this puzzle was originally put forward by W. Pauli in 1931 in a suggestion that perhaps two particles are emitted in the beta-decay and the same total energy in each case is divided between them in different ways in different individual occurrences of beta-decay, but that one particle is of such a nature that it escapes direct detection. Thus the evidence for the existence of the new particle became the need to account for the missing energy, just as a business man might infer the existence of a thief he never sees from the observed lack of the proper amount of cash in the till.

To carry off energy and escape detection, the particle would have to be electrically neutral and have a mass less than that of an electron. Enrico

Fermi called this hypothetical new particle the neutrino, the Italian for little neutron.

Accordingly, then, the basic process was this: one of the neutrons in the beta-active nucleus must have a certain probability of converting itself into a proton while simultaneously creating an electron and a neutrino which are then ejected from the nucleus. Using the mathematical formalism of quantum mechanics Fermi made certain plausible postulates about the process which proved fruitful in giving a detailed account of the shape of the continuous spectrum and the factors governing the rate at which beta-decay occurs.

In the years after 1934 this theory had extraordinary development. George Gamow (1904–) and Edward Teller (1908–) in 1936 introduced more general mathematical forms for the process. For twenty years this theory proved useful for correlating a wide range of details about beta-decay until in 1956 T. D. Lee and C. N. Yang discovered that the whole structure had been erected on a basis involving an incorrect assumption, known as the conservation of parity. This seemed at first to complicate matters by introducing many new theoretical possibilities, but it subsequently appeared that among these new possibilities are some which make it possible to complete the understanding of beta-decay theory in a very satisfying way.

(*d*) *Nuclear stability, artificial radioactivity and fission.* The naturally occurring radioactive atoms are thus energetically unstable and are found to disintegrate in two ways: by alpha particle emission and by beta and neutrino emission by the process just described. Most of the atoms known in nature are apparently quite stable and do not disintegrate in either of these ways. These questions, therefore, arise: what determines which kind of nuclei are stable, and are there other ways of disintegration that can relieve instability? Much of the work in nuclear physics in the 1930s and 1940s revolved around the study of these questions.

Study of the general problem of nuclear stability was greatly advanced during these years by the development of mass spectrographs of high precision. With these instruments the relative masses of most atomic species were known to a precision of better than one in a million. Even the earlier work was accurate enough to indicate that the mass of an atom is definitely less than the sum of the masses of its separated constituents, usually by amounts less than 1 per cent. This difference is called mass defect.

Mass defect is a direct consequence of the equivalence of mass and energy ($E = mc^2$) as discovered by Einstein in 1905. When an atom is formed by the coming together of its separated constituents energy is released which goes away carrying some of the mass with it, so the resulting atom has less mass than the materials from which it is made. If on the other hand an atom is unstable and spontaneously disintegrates into lighter atoms and particles with the release of energy, then the initial atom must have greater mass than the sum of the masses of the materials into which it disintegrates.

Thus the precise measure of atomic masses gives a direct indication of their

energy of formation or disintegration; this is the reason why so much effort continued to go into measuring atomic masses with the maximum precision attainable. The sum of the masses of a neutron and a hydrogen atom is 2·0171311 atomic mass units, which exceeds the mass of the deuterium atom by 0·0023886, which is proportional to the amount of energy released when a neutron is captured by a hydrogen atom to form a deuterium atom. Similarly, the mass of two deuterium atoms is 4·0294850, exceeding that of one ordinary helium atom by 0·025611. This is proportional to the amount of energy which would be released if a way could be found to cause deuterium atoms to join to make helium. Reactions like these do occur in the sun and stars to maintain their radiation, and they occur explosively in hydrogen bombs.

With the accumulation of the knowledge of large numbers of precise masses, the mass differences in various nuclear reactions could be correlated with experimentally measured energy release. In this way, thirty years after Einstein's theoretical discovery of mass-energy equivalence, that principle was quantitatively confirmed with high accuracy on dozens of nuclear reactions.

Trends of the measured masses show that the nuclei become unstable except in the narrow band of related (Z, N) values that characterize the naturally occurring nuclei. It is this fact which explains the occurrence of artificial radioactivity. In an (α,n) type of reaction an alpha particle (consisting of two protons and two neutrons) is caught and a neutron is emitted, so the result from bombardment of a nucleus containing Z protons and N neutrons (Z, N) is $(Z + 2, N + 1)$. If this is outside the band of stable nuclei it may be radioactive, i.e. it may spontaneously distintegrate. In 1934 Irene Curie (1897–1956) and her husband Fréderic Joliot-Curie (1900–) in Paris discovered instances in which the product was radioactive but emitted positrons instead of electrons. Thus it became clear that the process of beta-decay could include positron-neutrino emission by change of a proton into a neutron, as well as the originally discovered process of electron + neutrino emission by change of a neutron into a proton. Which occurs in a particular instance depends on whether the nucleus is unstable by having too many protons or too many neutrons. In the years which followed it became possible to make artificial radioactive isotopes of both types for nearly every element. These proved to be enormously valuable in chemistry and in biology.

Apart from their intrinsic importance, studies of artificial radioactivity were to lead in the next few years to the discovery of nuclear fission, the neutron chain reaction and the development of nuclear weapons. This chain of events started in 1934 when Fermi and associates, working in Rome, made a systematic study of the artificial radioactive isotopes produced by neutron capture in various elements. As this process produces a nucleus containing too many neutrons to be stable, the kind of beta-decay which occurs is electron + neutrino emission in which one of the excess neutrons changes into a proton.

Among the elements bombarded with neutrons by Fermi and his group was uranium. Adding a neutron to a nucleus puts it on the neutron-rich side of stability. Therefore if stability is acquired by beta-emission, an electron will be ejected and the atomic number is increased by one. By bombarding uranium with neutrons one might expect to produce atoms beyond uranium, the transuranic elements, which do not exist in nature. Fermi's group found a large variety of radioactive materials produced this way which were at first interpreted as being the new transuranic elements.

But in 1938 two chemists, Otto Hahn and F. Strassmann, showed that most of the observed activity due to the reaction of neutrons with uranium was not due to the expected formation of transuranic elements. Instead it was due to an unexpected new process called fission. In this the uranium nucleus, rendered highly unstable by the capture of a neutron, splits into two roughly equal parts which fly apart from each other with great speed. Further investigation showed that the direct fission products are not the same in each instance of each disintegration; instead, a wide variety of fission products is formed. These are all on the neutron-rich side of stability and so are radioactive with subsequent emission of negative beta particles.

An important feature of the fission process is the fact that, besides the two major fragments, there are on the average between two and three neutrons which get free. It is this fact that makes possible atomic bombs and the controlled release of power from uranium. Usual sources of neutrons are costly and weak. In the fission process one neutron is used to cause the fission and about three are released, so there is a gain of two. Hence if these two can be fully utilized to cause fission the next stage will give four, the next eight and so on. Such a multiplicative process is known as a chain reaction, and raises the possibility of producing very powerful neutron sources as well as the release of huge quantities of energy. (Pl. 1a.)

These basic ideas were all known to physicists of many countries within a few months of the discovery of fission, i.e. by the summer of 1940 when Hitler's armies had overrun the European continent and an invasion of Great Britain appeared imminent. That it might be possible to use a fission chain reaction as an explosive weapon was immediately obvious, and consideration of this possibility was under discussion in several countries.

Although the basic ideas underlying a possibly explosive chain reaction based on uranium fission were known, many of the quantitative parameters of the process were quite inaccurately known at the time. It was not certain that an explosion could actually be made to occur nor what minimum size was called for. What was known was that even to answer such questions would call for a vast amount of experimental research, expensive in materials and in the use of skilled manpower. If the project of making a uranium fission bomb could be carried out at all it would be at the price of an enormous effort, for which success could not with confidence be forecast in advance.

By the summer of 1940 military secrecy was imposed on this field of work

in various countries. In Germany the work was put under Werner Heisenberg; little progress, however, was made in the five years that remained of Hitler's régime. In Britain a project was also initiated but, with the intensification of the German aerial attacks on Britain, it became clear that a project of the necessary magnitude could not be carried on in that country. In the autumn of 1941 arrangements were made for the British to contribute their scientific talent to a combined effort with the United States to carry on a large project in the USA. With the entry of the United States into the war at the end of 1941 these plans were given high priority with the result that the first fission bomb was tested in June 1945 at Los Alamos, New Mexico, USA. When the USSR started its development work was not made public; however, the Soviet Union successfully tested such a bomb about three years later. (Pl. 1b.)

However far-reaching these events might be in military technology and international politics, they did not directly add appreciably to knowledge of fundamental science. They had some indirect effects, for now governments wished to spend much more on scientific research than ever before. Also the uranium reactors, built to supply the transuranic element plutonium ($Z = 94$), another fission bomb material, provided unlimited supplies of by-product radioactive materials which found wide applications in research in chemistry, in biology and in many areas of technology. In the early 1950s nuclear reactors, using the controlled uranium fission chain reaction to supply heat to make steam to drive steam turbines, had been developed in the United States to propel submarines and in various countries, principally in Britain and the USSR, to produce electric power.

(*e*) *Post-war period: cryogenics, solid-state physics, new elementary particles.* Three major areas of experimental research developed greatly in the post-war period. These were cryogenics, the study of the properties of matter at extremely low temperatures: solid-state physics, in which the results of experimental data such as X-ray spectra are combined with quantum mechanics of the electrons to give new insights concerning metals, semi-conductors and insulators; and the discovery and study of high-energy particles, in cosmic rays and through their artificial production in very large electrical particle accelerators. Many of the fundamental discoveries in these fields had been made earlier in the century. In the post-war period these older discoveries were exploited, many new discoveries were made and the total scientific activity in these fields increased enormously.

The study of the thermal properties of matter down to very low temperatures is needed to gain information about their chemical behaviour at ordinary temperatures. This fact long served as a major stimulus to cryogenic research. In addition there are two peculiar properties of special materials which occur only at temperatures where the thermal agitation of ultimate parts is greatly reduced. Certain metals exhibit the phenomenon known as superconductivity when they are colder than a certain temperature. In this state all resistance to the flow of electric current vanishes, so an electric current, once started,

flows indefinitely without appreciable diminution. The effect is more than a simple reduction to zero of the electrical resistance, for it is accompanied by unusual magnetic behaviour known after its discover, Walther Meissner (1882–), as the Meissner effect. At usual pressures helium becomes liquid at 4°K and then abruptly, when cooled below 2·18°K, changes over into a different liquid form which is called a superfluid because it is characterized by extraordinary flow properties. Its behaviour is as if the viscosity of the fluid abruptly became zero, analogous to the vanishing of the electrical resistance of a superconducting metal; but also the fluid shows other peculiar flow properties that require more sophisticated modes of description than merely saying that it has zero viscosity. A great deal of experimental and theoretical work went into the study of the superconducting and superfluid states but, as late as 1958, it could not be said that the basic principles were well understood.

In the field of solid-state physics many new experimental techniques were developed to measure the microstructure of solid matter. For example, the development of the field emission microscope greatly facilitated the study of surface phenomena and made it possible to attack such problems as the migration of tungsten atoms on the surface of a tungsten crystal. The technique of nuclear magnetic resonance, originally developed by nuclear physicists, permitted solid-state physicists to explore the internal magnetic fields occurring in solids and molecules. The well-established method of studying crystal structure by X-ray diffraction was supplemented by neutron diffraction. One advantage of this new method is that, in contrast to X-ray diffraction, it permits the identification of the position of light atoms such as hydrogen in a crystal containing heavy atoms.

The older method of X-ray crystallography provided the means for determining the detailed arrangement of atoms in crystals. Since the arrangement of atoms in a large molecule is not much affected by the circumstance of the molecule's being in a crystal, X-ray diffraction becomes more generally a tool for studying the structure of complicated molecules. Here a basic discovery was developed to the point where structural crystallographic work became a professional speciality in its own right, with distinct areas of specialization within it according to the worker's interests in amorphous materials like glass and organic polymers, metals and alloys, silicate minerals, or proteins and other macromolecular compounds of biochemical interest.

X-ray crystallography was making rapid progress toward the detailed determination of the structure of proteins and of the deoxyribonucleic acids which appear to be the stuff determining modes of life, growth and heredity of most living things.*

To physicists one of the most exciting new frontiers to be opened up was the study of a whole new class of high-energy particles whose presence was first detected in cosmic rays. This field of work originated with a sugges-

* *Infra*, Chapter XIII.

tion by H. Yukawa in 1935 that an understanding of the forces which hold the atomic nucleus together would be facilitated by supposing the existence of a new type of particle, intermediate in mass between electrons and the 1,836 times more massive nucleons. Because they were intermediate in mass they were called mesons. Two years later the Yukawa hypothesis seemed to receive a beautiful confirmation when, independently, such mesons were discovered in cosmic rays. However, it soon appeared that the story was more complicated than was at first supposed because these experimentally discovered mesons were found to interact with nuclei so weakly that they could not possibly be the agents of the nucleon-nucleon interaction for which purpose Yukawa first postulated their existence. This meant that either Yukawa's idea was wrong or another kind of meson remained to be discovered.

The war caused a long hiatus in which physicists could not follow the challenge of this dilemma. A full decade elapsed until the discovery in 1947 of the other kind of strongly interacting mesons which behave more like those which Yukawa had postulated. These were found in high-altitude cosmic-ray studies, whereas the kind found earlier were most abundant at lower altitudes in the earth's atmosphere.

Mesons became the object of intensive study by physicists all over the world. To distinguish them, the ones occurring at high altitudes which interact strongly with nucleons are called π-mesons or pions; and those occurring at low-altitudes which interact weakly with nucleons are called μ-mesons or muons. Pions were found to be of three types, the electrically neutral, and those having either a positive or a negative electric charge of the same amount as that of an electron. The positive pions and negative pions seem to have the same mass, 273 times that of the electron, but the neutral pion has a smaller mass, 264 times the electron mass. The muons are always charged, positively or negatively, the amount of charge being the same as that of the electron. No evidence for a neutral muon had been found. Both positive and negative muons have a mass 206·8 times that of the electron, definitely less than the mass of either neutral or charged pions.

The pions and muons are all unstable, disintegrating spontaneously into other particles in small fractions of a second. For this reason they cannot be the primary cosmic radiation. Rather it was thought that the primary cosmic radiation consists mainly of high-energy protons with a lesser component of high-energy nuclei of several other kinds of light atoms. How these nuclei get their energy and whence they come was one of the great unsolved problems of astronomy. Encountering the outer layers of the earth's atmosphere they collide with nuclei of these atoms and generate pions by processes which in 1948 were reproduced in the laboratory with the large synchrocyclotron at Berkeley, California.

The charged pions spontaneously decay in flight within one hundred millionths of a second, giving rise to muons of the same charge and presumably neutrinos and anti-neutrinos. The neutral pions have a life that is a million

times shorter, decaying into gamma rays, or into gamma rays and electron-positron pairs. The charged muons in turn decay into electrons or positrons accompanied by neutrino and anti-neutrino pairs. This they do at a rate that is one hundred times slower than that of the decay of the charged pion, so that the muons have a mean life of 2·2 microseconds.

Just when physicists were getting the relations and properties of these mesons worked out, the picture was further complicated by the discovery of several more kinds of unstable particles in cosmic radiation. These are charged and uncharged K-particles, or kayons, of about 966 electron masses, the uncharged lambda (Λ^0) particle of about 2,181 electron masses, hence more massive than the normal protons and neutrons, and the charged (±) and neutral sigma particles (Σ) of masses around 2,330 times that of electron, and probably others. Those whose mass exceeds that of normal protons and neutrons are called hyperons, so there are Λ and Σ^+, Σ^- and Σ^0 and other kinds of hyperons. The mesons include the kayons and the various pions and muons. Finally, in 1955 the negative proton was discovered in Berkeley, California, by Emilio Segre (1905–) and associates.

This unexpected wealth of unstable particles opened up a vast range of new problems for experimental and theoretical research. At first the experimental study was held back by the extremely small numbers of such particles that occur in the natural cosmic radiation. In 1930 nuclear physics had been limited in a similar way. The sources of natural radioactive particles used by Rutherford were too weak to allow much further advance. The development of the cyclotron and other accelerators allowed the use of intense beams of protons, deuterons and alpha particles, and from the results of experiments using such beams the properties of these particles were discovered. Very large accelerators were therefore being built to produce beams of these new unstable particles, and by means of similar experiments to permit the working out of their properties.

The understanding of matter developed during the first half of the twentieth century was sufficiently complete to serve as a fundamental basis for all chemistry, all of atomic physics and most of nuclear physics. But it did not yet provide an ultimate theory of matter. The study of why particles of certain masses are stable and others are not, the characteristics of these particles and their interactions was the main frontier in the quest for such an ultimate theory.

III. THE NATURE OF THE EARTH

The new theory of matter brought new insight into the nature of the earth and unity into the study of its surface, its atmosphere and its deep interior. It began to transform geology from a mainly descriptive science to an experimental and theoretical one, although at mid-century much knowledge of the earth remained at the descriptive level.

1. *The surface of the earth*

By the opening of the twentieth century the description and classification of rocks was well advanced. Although geology was a late-comer among the physical sciences and the revision of ancient and medieval notions of the earth did not begin until the end of the eighteenth century, extensive work in palaeontology and petrography during the nineteenth century had established these largely descriptive fields.

In palaeontology the French biologist Georges Cuvier (1769–1832) led the way in showing how scraps of bones in gypsum deposits could be combined with an understanding of anatomy to reconstruct the form of an animal never before seen by man. As a result of the labours of nineteenth-century palaeontologists extinct organisms were classed into species, genera and orders which gave a new dimension to descriptive biology. In combination with Darwin's great synthesis of biological data in his *Origin of Species*, this detailed and tedious work had an incalculable impact on man's concept of his place in nature.

In petrography, the description and classification of rocks, perhaps the most significant single development during the nineteenth century, arose from a technical invention. The polarizing microscope, invented by the Scottish physicist William Nicol (1768–1851) in 1828, had made it possible for the petrographer to examine thin sections of dense rock in the same detailed way that a biologist examines the cells of a plant or animal. As the nineteenth century ended, petrography led to the new science of petrology in which emphasis shifted from the description of rocks to the problems of their genesis and distribution. This shift in emphasis was made possible both by the great wealth of petrographical data which had been accumulated and by the growing understanding and synthesis of physics and chemistry.

During the twentieth century geologists came to realize that the crystallization of rocks such as basalt and granite follows the same laws of physical chemistry as the crystallization of chemical compounds in the laboratory. By application of reasoning based on understanding of these laws of physical chemistry petrologists were able to show that some of the facile explanations of geological phenomena previously advanced could not be correct.

For example, one of the major problems of geology is to explain the diversity of rock types. In a small region of a few kilometres extent one often finds different igneous rocks which nevertheless probably had a common origin. This phenomenon had usually been explained as resulting from 'liquid immiscibility'. It is a well-known fact of experience that certain liquids do not mix with one another, for example oil and water. It had been supposed that, upon cooling, an initially homogeneous mass of molten rock, called a magma, split into two or more immiscible liquid fractions which then crystallized to give the different types of rocks which are observed. N. L. Bowen (1887–1956) showed the result of such a process would be entirely

different from what is observed in nature. According to his reasoning the rocks which result would contain many minute droplets of material of different chemical composition rather than distinct homogeneous rocks as observed in the field. Furthermore, careful laboratory experiments indicated that melts of the composition of the observed rocks could actually be mixed in all proportions. Thus the explanation failed on two counts.

Bowen then suggested an alternative explanation which did fit with the facts of physical chemistry. After various minerals have successively crystallized from the magma to form one type of rock, physical forces such as gravity separate these crystals from the residual magma. As a result of the subtraction of the chemical compounds in these early crystals, the chemical composition of the magma has been changed. The subsequent crystallization of the residual magma therefore produces a different type of rock. Repetition of this process of fractional crystallization can result in the type of variation observed in nature. Similar combinations of physical reasoning and careful laboratory work enabled petrologists to learn much about the actual processes by which rocks are formed in nature, although many fundamental questions remained unanswered.

Bowen's theory of differentiation due to crystallization did not, however, provide a complete solution to the problem of the diversity of volcanic rocks, in particular to their division into the two main groups of basalts and granites. In the second quarter of the twentieth century new ideas began to gain ground. According to these, granites were not formed as a result of intrusion from below of a magma or the late crystallization products of a basalt magma but as the result of the change—granitification—of various older sedimentary, metamorphic and volcanic rocks due to the displacement of their minerals by feldspars and quartz upon the deposition of alkalis (K, Na) and silica and upon the removal of the superfluous alkali earth (Ca, Mg) and iron. The magma origin or metasomatic origin of granites, and the mechanism of granitification assumed in the latter case, remained highly controversial questions.

2. *The age of the earth*

One of the major problems in geology is the question of the age of the earth. At the opening of the nineteenth century most men in the Christian world, including scientists, had accepted the view that the earth was only about 6,000 years old. As a consequence of this belief it had been necessary for geologists to squeeze all the events which combined to produce the present geological record into this short length of time.

The work of the great pioneer geologists James Hutton (1726–97) and Charles Lyell (1797–1875) helped to free the science from this encumbering opinion. They presented striking evidence that the geological record was the product of ordinary familiar causes, such as erosion, operating over great expanses of time. The need for a longer time-scale was accentuated by the

requirements of the evolutionists later in the nineteenth century and it appeared that the earth must be hundreds of millions of years old rather than merely a few thousands.

No sooner had this scientific opinion prevailed over the theological one than it was challenged from another source, the calculations of the British physicist Lord Kelvin (1824–1907), who concluded that the earth and sun could be but a few tens of millions of years old. Consideration of the known sources of solar energy led Kelvin to believe that the sun could not have been radiating heat for more than about a hundred million years; furthermore, if the earth were originally molten its surface regions would have cooled sufficiently in about twenty-five million years to conflict with the observed rise in temperature encountered in deep mines. These conclusions seemed formidable at the time, and they gave rise to serious controversies.

The discussion was soon ended, however, in a most unexpected way by the first contribution of nuclear physics to geology, the discovery of radioactivity in 1896. This discovery showed that the radioactive elements uranium and thorium formed an almost inexhaustible source of heat which had not been included in the calculations of Kelvin, and which would suffice to produce heat in the earth for many thousands of millions of years. By the 1930s it was realized that the heat of the sun is caused by a different type of nuclear effect, the fusion of hydrogen nuclei into the nuclei of helium, accompanied by the production of heat.

During the twentieth century radioactive decay contributed to knowledge of the age of the earth in another way. It was soon realized that the radioactive transformation of uranium and thorium into lead furnishes the basis for an absolute method of geological age determination. Minerals such as uraninite contain uranium and thorium but initially very little lead. As time goes by the uranium and thorium in the mineral decay into lead at a known rate. By measuring the total amount of lead produced in this way, together with the amount of uranium and thorium, one can calculate the time which has elapsed since the original formation of the mineral. The first ages calculated by this method were published in 1907 and showed that many of the rocks on the earth were hundreds of millions of years old. Although the nature of the radioactive transformation was little understood, these early age-determinations were approximately correct and the subsequent development of nuclear physics and of powerful new analytical techniques made it possible to date a great many geological occurrences in this way.

After the second world war the older methods based on the disintegration of uranium and thorium into lead were supplemented by new methods which utilized in a similar way the disintegration of potassium into argon and rubidium into strontium. As a result of these measurements ages as great as 3,400 million years were found in the Kola peninsula of the Soviet Union, and rocks at least 2,500 million years old were found in many places throughout the world. The earth itself must be older than this, but just how much

older was hard to say. Indirect arguments based on comparison of the ratios of the isotopes of lead on the earth with the corresponding ratios in iron meteorites indicated a probable age for the earth of about 4,500 million years.

Nuclear physics made a number of other contributions to geology. Measurement of ages by the amount of radioactive carbon present in geological materials and in organic residues contributed to the study of more recent geological history, which includes such events as the great ice ages. This was in addition to the great importance of carbon-dating for archaeological studies. Still another example of the application of nuclear physics to geology was the work initiated by H. C. Urey and his colleagues in which variations in the ratios of stable isotopes of the light elements hydrogen, carbon and oxygen were utilized in geological investigations. Continuation of this work yielded information concerning such problems as the temperatures of the prehistoric oceans, the origin of natural waters and the fractional crystallization of a magma.

3. *The interior of the earth*

In the nineteenth century geological thinking had been concerned almost exclusively with the surface features of the earth. Relatively little was known about its interior. From astronomical measurements it was possible to calculate the total mass of the earth as well as the fact that this mass was concentrated toward the centre of the earth. Measurement of the temperature in mines apparently indicated that the interior of the earth was much hotter than the surface. Extrapolation of these thermal gradients led to the conclusion that the deep interior of the earth is so hot that it is liquid, if not gaseous. But from observations of earth tides, Lord Kelvin arrived at the opposite conclusion, that the earth as a whole is very rigid.

Great advances in the understanding of the earth's interior were made during the twentieth century. These advances were largely due to the growth of seismology, the study of earthquakes. An earthquake is caused by the sudden fracture of rocks within the earth—usually near the surface of the earth. As a consequence of this fracturing, waves are radiated which are sufficiently strong to penetrate the entire earth. These seismic waves are mechanical vibrations like sound waves, but are mostly too low in frequency to be audible to the human ear. Other seismic waves are formed which travel along the surface of the earth. By combining the classical theory of elastic wave propagation with observations of these seismic waves, seismologists succeeded in deducing much information concerning the structure of the earth's interior. In fact these seismic waves were almost the only practical way to probe the deep interior of the earth.

Early in the century studies of seismic waves showed that the earth is divided into two principal regions—the core, largely liquid with a radius of about 3,500 kilometres, surmounted by a solid shell called the mantle about 2,900 kilometres thick. In 1909 A. Mohorovičić (1857–1936) in Zagreb

discovered that above the mantle is a thin skin of lower density which has been named the crust. The boundary between the crust and the mantle was named the Mohorovičić discontinuity in honour of its discoverer. Underneath most of the continental regions it lies at a depth of about 35 kilometres below the surface of the earth, while under the oceans it occurs at a much shallower depth.

As a result of much detailed work seismologists were able to give a fairly exact account of the way in which the velocity of sound waves varies with depth, and from these results it proved possible to infer the variation of density with depth as well as other properties of the earth's interior. After the second world war seismic studies were aided by the use of man-made explosions to replace earthquakes as a source of seismic waves. This method had the advantage that the time and place of the initial shock were accurately known and did not have to be calculated from the observations as is the case with earthquakes. Using chemical explosions, seismic studies of the earth's crust were made on several continents as well as at sea, and nuclear explosions produced seismic waves sufficiently strong to penetrate the deep interior of the earth. Data from these nuclear explosions gave further information bearing on the existence and properties of a solid inner core within the liquid core of the earth.

At the same time much thought was given to the nature of the Mohorovičić discontinuity which forms the base of the crust. For many years it had been assumed to represent a chemical discontinuity; the crystal rocks were thought to contain a high concentration of the lighter elements, while upon entering the mantle the composition was thought to change abruptly to rocks richer in iron compounds and having a greater density. However, support increased for the view that there is no major chemical change at the Mohorovičić discontinuity but that the observed increase in density at this depth arises from the presence of high-pressure modifications of familiar minerals. Laboratory work in which a number of these high-pressure modifications appeared at pressures and temperatures appropriate to the depth of the Mohorovičić discontinuity strengthened this surmise and was one of the considerations which led to plans to drill a deep hole through the discontinuity into the mantle to put the hypothesis to a direct test.

4. *The atmosphere of the earth*

During the twentieth century substantial information was accumulated about the earth's atmosphere as well as about its interior.

In the nineteenth century it was known that as one goes higher in the atmosphere, to heights of a few kilometres in balloons or on mountains, the air becomes less dense and the temperature drops. It was generally thought that if one went to greater elevations the density and temperature would steadily decrease, the density approaching zero and the temperature approaching −273°C, the absolute zero of temperature.

About the turn of the century Léon P. Teisserenc de Bort (1855–1913) in Paris sent balloons to altitudes of about 14 kilometres and discovered the surprising fact that above about 11 kilometres the temperature no longer dropped but assumed a constant value of −60°C. Thus it was discovered that the earth's atmosphere consists of at least two layers; the lower he named the troposphere, and the upper region the stratosphere. The boundary between these two layers is known as the tropopause, where the famous belt of high wind called the jet stream is found. Most ordinary weather phenomena such as clouds and storms take place in the troposphere, although it appeared possible that the stratosphere might be important in practical meteorology.

In the period prior to the second world war the greatest altitude accessible to direct observation by unmanned balloons was about 30 kilometres. However, the inability of scientists to probe the upper atmosphere directly did not prevent them from investigating its properties. Increased understanding of the nature and properties of matter combined with new observational techniques made it possible to infer much about the upper atmosphere from measurements made at the ground.

One important indirect method for probing the stratosphere was developed as a consequence of the observation that guns fired in London at Queen Victoria's funeral were heard unusually far to the north, and that during the first world war artillery fire from the Western front was frequently heard in England. It was shown that the sound waves which were radiated toward the sky were being refracted back to earth because of a temperature gradient in the atmosphere above the constant-temperature region discovered by Teisserenc de Bort.

By careful study of this phenomenon it was shown that the temperature actually increases in the region from 30 to 60 kilometres and that at the height of 60 kilometres the air temperature is about 90° C, considerably hotter than the temperature at sea-level. Studies of the velocity and luminosity of meteors, principally by Fred L. Whipple (1906–), led to the same conclusion for the region from 30 to 60 kilometres and showed further that the temperature then decreases well below 0° C at an altitude of 80 kilometres and then begins slowly to rise again at greater altitudes. Thus the temperature variation in the atmosphere proved to be quite complex in contrast to the simple uniform decrease accepted at the beginning of the century. The observations on meteors also provided data on the density of the atmosphere up to an altitude of about 100 kilometres.

Concern with problems of electrical conductivity led to the identification of a third layer, known as the ionosphere. At the surface of the earth most of the very short wavelength, ultra-violet radiation from the sun has been absorbed by the atmosphere. However, in the stratosphere and above, high-energy protons are able to break chemical bonds and thus induce a number of photochemical effects. One of the most important of these effects is the con-

version of small amounts of oxygen into ozone in the region from 20 to 50 kilometres, as demonstrated in 1934 by measurement of the absorption bands of ozone in the solar spectrum. It is this ozone which is responsible for absorbing most of the biologically harmful ultra-violet radiation. At even greater altitudes the ultra-violet radiation is effective in removing electrons from normally neutral atoms to form positive ions. The presence of these free charged particles, electrons and ions, causes the atmosphere to become a good electrical conductor above an altitude of 70 kilometres.

Late in the nineteenth century it had been suggested that there was a conducting layer somewhere in the atmosphere, in order to explain the day-to-day variations in the earth's magnetic field. Little attention was paid to this suggestion and it was almost forgotten at the time Guglielmo Marconi (1874–1937) made his pioneer investigations in radio transmission in 1901. Since physicists had shown that radio waves travel in straight lines like light it had been expected that the curvature of the earth would prevent long-distance transmission of radio signals. Nevertheless Marconi succeeded in sending signals across the Atlantic.

The idea of a conducting layer which would reflect the radio waves back to earth was then revived by Arthur E. Kennelly (1861–1939) in the USA and Oliver Heaviside (1850–1925) in Britain. That radio waves from a distant station do indeed come down from the sky was demonstrated in Britain by Edward Appleton (1892–) and M. A. F. Barnett (1901–) in 1924. In 1925 Gregory Breit (1899–) and Merle A. Tuve (1901–) in the USA demonstrated beyond doubt the existence of the conducting layer by a technique which was the forerunner of radar. Radio signals were transmitted vertically into the sky and echoes were received from the conducting layer. By measuring the time required for the radio signal to go up and back, the height of the conducting layer was determined.

This conducting region forms the third major division of the atmosphere, the ionosphere. It was found that the ionosphere contains several layers of different conductivity which are designated in order of increasing height as the D, E, F and F_1 layers, the last beginning at an altitude of about 250 km. The part of the atmosphere beyond the ionosphere is called the exosphere. Here the density of the atmosphere is so low that individual atoms and molecules seldom collide with one another and thus are able to revolve in satellite-like orbits around the earth.

The development of the V-2 rocket by Germany in the second world war provided a means for direct probing of the upper stratosphere and ionosphere. After the end of the war many V-2 rockets, and later rockets of more advanced designs, were fired into the upper atmosphere. The accuracy of the earlier data was greatly improved but on the whole these direct observations were in agreement with the conclusions already obtained by indirect methods. After 1957 the use of artificial satellites provided a way of making a sustained series of observations in the ionosphere and exosphere. It was expected that the

continued development of this approach would result in many highly instrumented and possibly manned observing stations in the upper atmosphere and would thus greatly facilitate the collection of information regarding this outermost region of the earth.

IV. THE NATURE OF THE UNIVERSE

At the opening of the twentieth century the motions of the planets and satellites of the solar system were understood in precise detail. To a high degree of accuracy they were fully predictable on the basis of calculations based on Newton's laws of motion and Newton's inverse square law of gravitation. Only in the case of the planet nearest the sun, Mercury, was there a discrepancy: the direction of perihelion was observed to advance by a measurably larger amount than could be accounted for by perturbations by the other planets. This last discrepancy was removed by substituting (1916) a slightly modified law of gravitation from Einstein's General Theory of Relativity which explained the advance of Mercury's perihelion without spoiling the vast number of other details in which Einstein's and Newton's laws each agree equally well with observations. Although refinements of detail continued to be made, astronomers thereafter regarded celestial mechanics as essentially a fully worked out branch of their science.

The attention of astronomers therefore turned more and more to stellar astronomy, including the study of the sun and of the gaseous and dust clouds of interstellar space. They examined the distribution in space of stars and of clouds of dust and gas, and the structure, constitution and evolutionary development of these astronomical phenomena.

1. *New techniques of observation*

Prior to 1932 all data studied were based on observation of the visible, near-ultra-violet and near-infra-red light emitted by the stars that is able to penetrate the earth's atmosphere. Early in the century effort was concentrated on building larger telescopes for dealing with this light; the largest projects were construction of the 100-in. reflector on Mt Wilson and later the 200-in. Hale reflector on Palomar Mountain, both in southern California. At the same time there was a steady increase in the large telescope facilities in the southern hemisphere, especially at the Mt Stromlo observatory of the Australian National University near Canberra. Improvement of southern hemisphere facilities was of especial importance, for it became known that this part of the sky contains more objects of fundamental interest than does the northern. (Pl. 2a.)

An entirely new method of stellar observation was made possible by the discovery that certain radio waves come from interstellar space. Radio astronomy makes use of the transparency of the earth's atmosphere to electromagnetic waves in the range of wavelengths from 1 cm. to about 10 metres.

The source of such radio waves was discovered in 1932 by Karl Jansky (1905–50) in New Jersey and knowledge of them extended by Grote Reber (1911–) in Illinois in the following years. After the second world war this field of study was cultivated vigorously in many countries, particularly by the Australian radio physicists. Very great expansions of astronomical knowledge were expected as a result of the construction of many large radio telescopes, which are large paraboloidal metal reflectors at the foci of which are placed receiving antennae for picking up the received radio waves and leading their energy to amplifying and recording devices. (Pl. 2b.)

The scope of astronomical observation was still further extended when it became technically possible to make observations with instruments carried above the opaque blanket of the earth's atmosphere. At mid-century many observations in the far-ultra-violet were being made with instruments carried aloft by rockets or high-altitude balloons, or by combinations of both in which a rocket was carried by balloon most of the way to the top of the earth's atmosphere and then fired vertically upward. Such techniques opened the possibility of knowing much more about detailed mechanisms by which changing solar conditions affect the earth.

Toward the end of 1957 a great impetus to studies of this kind was given by the successful launching by the Russians of the first artificial earth satellite. They demonstrated the feasibility of putting into an orbit several hundred miles above the earth's surface an object of several thousand pounds weight that can be equipped with astronomical observing equipment and means for automatically transmitting the data of observation by radio to stations on the earth. Because such satellites can remain above the earth's atmosphere continuously for many months or even years, they can accumulate data much more effectively than occasional rocket shots of a few moments' duration. (Fig. 2.)

2. *The distribution of stars in space*

At the beginning of the twentieth century the distance of stars was determined by measuring trigonometric parallax—the shift in their apparent direction from the observer due to the orbital motion of the earth around the sun. But the stars are mostly so far away that only very few of them give a measurable parallactic displacement, even though displacements as small as 0·01 sec. of arc were measurable by mid twentieth-century techniques.

A star at a distance such that the radius of the earth's orbit subtends an angle of 1 sec. at the star is said to be at a distance of 1 parsec. which is equal to 206,265 times the earth–sun distance. A light-year is the distance light goes in one year, which is 5·88 million million miles. A parsec is 3·26 light-years or about 19 million million miles. Only about 5,000 stars are near enough for direct measurement of their distance by the parallax method.

A great advance was made early in the century with the discovery by

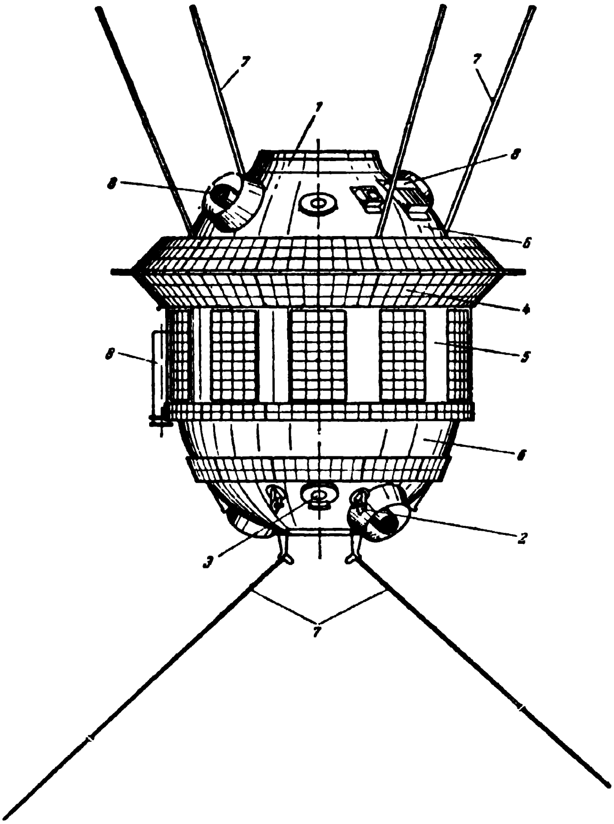


FIG. 2. Diagram of the Russian satellite Lunik III, the automatic interplanetary station which photographed the far side of the moon. 1: illuminator for photographic apparatus; 2: motor for guiding system; 3: solar pickup; 4: sections of solar battery; 5: shutters of temperature control system; 6: heat screens; 7: aerials; 8: apparatus for scientific investigations. (See plate 3b.)

Henrietta Leavitt (1868–1921) and Harlow Shapley (1885–) of a new way of determining stellar distances. There is a type of variable star called a Cepheid variable, of which thousands are known, whose brightness dwindles slowly and then rises abruptly. The time for one cycle of such brightness variation is called a period. Working on stars which are near enough for their distance to be measured by the parallax method, Miss Leavitt discovered a relation between this period of variation and the absolute mean brightness, i.e. its brightness as seen at a standard distance. The brighter the star the longer the period. Shapley recognized that, since the observed period of such a Cepheid variable tells its absolute mean brightness, astronomers could use this together with its observed apparent mean brightness to infer its distance away from us. The method was widely used during the first half of the century, and with the large telescopes gave distances for this kind of star out to far greater limits than is possible with the parallax method.

The twentieth century saw a great advance also in understanding the relationship of the sun and solar system to the rest of the stars in space. The most obvious organization of the stars in space is the plainly visible Milky Way, a band in the sky near which there is an unusually great density of visible stars. In this aggregation of stars, known as 'our' galaxy to distinguish it from the several hundred million other similar aggregations which make up the known universe, the great circle which passes through the densest parts is called the galactic equator. The fact that the number of visible stars thins out rapidly in directions away from the galactic equator indicates that the galaxy is a vast disc-shaped region occupied by stars.

Prior to the twentieth century the fact that the density of stars at various places around the galactic equator is roughly the same was thought to indicate that the sun's location is near the centre of our galaxy. But researches of Shapley in the 1920s on distribution of globular clusters of stars showed this not to be so, and led to estimates that our solar system lies about 9,000 parsecs from the centre of the galaxy and that the diameter of the galaxy is 30,000 parsecs and its thickness about one-tenth as much. These dimensions are roughly ten times greater than the estimates that were prevalent in the nineteenth century.

Possibilities of probing the structure of our galaxy to its centre were opened up by the development of radio astronomy. Towards the centre of the galaxy and near its plane there is a vast amount of dust and interstellar gas that tends to obscure the light coming from these directions and make the Milky Way look not much brighter toward the galactic centre (in Sagittarius) than in the opposite direction. Radio waves, however, are less obscured by dust than is visible light. Observations revealed that the stars of our galaxy seem to be more numerous along several spiral arms out from the centre, indicating that the general structure of our galaxy resembles that of the spiral galaxies external to ours that can be seen as telescopic objects.[8]

Motions of a few nearby stars relative to us can be calculated from direct

observation of slow change of their apparent direction. But a much more important method, since it is not limited to the nearby stars, was derived from the Doppler effect. This technique was first developed in the late nineteenth century and made the basis of a vast amount of observational work during the next seventy-five years. According to this the lines in the spectrum of a light source that is moving towards the observer are shifted in wavelength toward the violet and, if moving away, toward the red. The amount of the wavelength shift is measured and serves as a direct indication of the speed of motion, or radial velocity, towards or away from the observer.[9]

From this technique came the discovery of spectroscopic binaries. These are pairs of stars which revolve around each other so close together that they cannot be resolved as two in the largest telescopes but whose motions are clearly revealed by the regular variation of the wavelength shifts in their spectrum, as their orbital motion causes first one and then the other of them to move towards us while the other moves away. In the second quarter of the twentieth century statistical study of the radial velocities of stars in our galaxy in different directions from us furnished a basis for an overall picture of the motions in the galaxy. The picture that emerged was of a good deal of random chaotic motion of the stars in the galaxy, superimposed on an orderly motion of rotation around the centre. As with the planets in the solar system, the period of revolution is longer at greater distances from the centre. At the sun's distance from the centre the period of revolution is about 200 million years. From this it appears that the total mass of the galaxy is of the order of one hundred thousand million times that of the sun. Perhaps half of this is in stars and the other half is spread out in interstellar dust and gas.

Outside our galaxy a vast number of other galaxies were known whose sizes are roughly comparable with that of ours, and whose distances apart are large compared with their own dimensions. Nearest to ours are the Magellanic clouds, two irregularly shaped aggregations about 25,000 parsecs away, and each about one-tenth the diameter of our galaxy. The two nearest and best-studied spiral galaxies are Messier 31 in Andromeda and Messier 33 in Triangulum each about 500,000 parsecs from us—about twenty times as far from us as the diameter of our own galaxy. (Pl. 3a.)

During the first half of the century, astronomers devoted a great deal of attention to the study of these galaxies external to ours, particularly at Harvard, at Mt Wilson and at the Lick Observatory in California. Edwin P. Hubble of the Mt Wilson Observatory estimated that about 100,000,000 of them existed within the range of instruments then available. In directions away from the plane of our Milky Way they show a remarkable statistical uniformity of numbers. The marked apparent absence of them in directions near the Milky Way was therefore taken as evidence that the uniformity of their numbers in all directions is masked by the obscuring effect of clouds of dust and gas in our own galaxy.

Thus the picture as developed during the first half of the twentieth

century was that man lived on a little planet going around one of the millions of stars in our galaxy which is but one among millions of similar galaxies in the known universe.

The discovery concerning external galaxies that excited the most attention and speculation was that made at Mt Wilson by Hubble. By studying the spectra of the light from these galaxies he found the lines to be shifted toward the red. Interpreted as Doppler shifts, this gives evidence that the galaxies are moving away from us. He found, moreover, that the fainter ones which it is natural to suppose are the most distant ones have greater red shifts; in fact the data are most simply interpreted by supposing a proportionality of the speed of motion of a galaxy away from us to its actual distance from us.[10]

This showed the universe to be expanding. Hubble's rule of proportionality of speed to distance seemed to apply out to the limit of the faintest objects that could be reached with the great telescopes in California.

3. *The structure and development of individual stars*

Along with this enlarged view of the extent of the universe came a rapid development of knowledge concerning individual stars, such as the sun. While earlier observers merely estimated apparent brightness of total light and made rough qualitative remarks about colour, the subject was completely transformed in the late nineteenth century with the introduction of the spectroscope, making possible detailed analysis of the light emitted by a star. In the twentieth century, study of stellar spectra progressed with the scientists' increasing ability to interpret spectra as revealing specific details about chemical composition and physical conditions in the source emitting the light.

From these studies the great fact emerged that the stars are made of the same chemical substances as occur on earth. The lines of varying width and intensity in the solar spectra are characteristic of the kinds of atoms and molecules in the star's outer atmosphere and of the physical conditions of temperature and gas pressure existing in the stellar atmosphere. They serve to show which chemical elements are present in the stars because of agreement of the wavelengths registered with those produced in terrestrial sources of known composition.

The relative intensity of the different lines in the spectra, including the question of presence or absence, varies greatly from star to star. On the basis of study of many tens of thousands of stellar spectra, a system of classification into spectral types was devised, largely the work of Annie J. Cannon (1863–1941) of Harvard University which came into universal use. The vast amount of attention given by astronomers to stellar spectroscopy was indicated by the details on the spectra of 225,000 stars contained in the Henry Draper Catalogue of Stellar Spectra, published (1885–1924) by the Harvard College Observatory.

A great step forward in understanding the relation between the intensity of the spectral lines and the physical condition in a star's atmosphere was

made by Megh Nad Saha (1893–1956) of Calcutta. He applied general thermodynamic theory to the problem. From this work emerged the surprising fact that the great observed differences in stellar spectra are mostly due to differences in temperature and density, with the chemical composition of the stellar atmospheres being nearly the same. Such studies showed that the stellar atmospheres are more than 98 per cent hydrogen and helium. Oxygen and magnesium make up another 1 per cent, leaving less than 1 per cent for all other elements.

With the rapid accumulation of large amounts of quite precise information about stellar atmospheres and with the great development of physical theories of atomic structure that occurred in the first half of the twentieth century, it began to be intellectually profitable to inquire into the internal constitution of stars, the nature of the source of the energy which they continually radiate, their genesis and the paths and time-scales of their evolution. The second quarter of the century was particularly fruitful in the development of theories dealing with these questions.

In the nineteenth century the only energy source known was that involved in the release of gravitational energy by steady contraction of the star. But calculation showed that such a source could not maintain the sun's radiation for more than about a hundred million years whereas there is ample geological evidence that the climatic conditions on the earth have been roughly the same for a hundred times longer than that. Discovery of radioactivity and the subsequent development of nuclear physics very early gave rise to the idea that the necessary energy source must involve nuclear changes related to atomic transmutations. But ideas of this kind had to remain vague and unspecific until 1936 when enough progress in nuclear physics had occurred to enable Hans A. Bethe in the USA and C. F. von Weizsäcker (1912–) in Germany to produce detailed and specific nuclear mechanisms by which energy could be released under conditions that actually prevail in stellar interiors.

At mid-century astronomers were far from having an adequate understanding of the genesis and development of stars. These were generally supposed to get started by gravitational contraction of interstellar gas and dust; at this stage the energy liberated by gravitational contraction heats the material up to a temperature of some ten million degrees, at which nuclear reactions can occur to provide the supply of energy needed for the full life-cycle of the star's development. But the specific details of such processes were not yet fully worked out.

V. THE APPLICATION OF BASIC SCIENCE TO TECHNOLOGY

The discoveries which brought advances in basic understanding of the nature of matter, of the earth and of the universe were made for the most part by men motivated solely by a desire for increased knowledge of the physical world. The extent to which these basic discoveries were exploited technolo-

gically and made the basis for industrial and other developments varied greatly from field to field. All of the major advances in the field of communication can be traced to the fundamental scientific discoveries of Faraday, Maxwell and Hertz as developed by engineers and inventors such as Alexander Graham Bell, (1847–1922), Thomas A. Edison (1874–1931) and Marconi. An outgrowth of the communication industry, the electronics industry, also had strong ties to the basic research of the late nineteenth and early twentieth centuries.

In contrast to this, the field of transport developed largely without the aid of workers in the fundamental sciences. At first this was even true of aeronautics, where it might have been expected that the classical science of aerodynamics would have played a fundamental role. However, unlike classical electromagnetic theory, the classical aerodynamics was principally concerned with the solution of mathematical problems of little practical interest, and the early understanding of the principles of flight was left to engineers to discover empirically. Through the work of Ludwig Prandtl (1875–1953), Theodore von Karman (1881–) and others, the physical basis of the principles of practical aerodynamics were gradually understood. After the second world war there was a major emphasis on applying fundamental physics to problems of aeronautics in university research centres, government laboratories and industrial research facilities.

While the development of the theory of the nuclear atom and quantum mechanics seemed at first to be far removed from practical application, the insight which these discoveries gave to the nature of matter was of great technological importance, notably to chemistry and to solid-state physics. A great amount of fundamental research in the latter field was undertaken in industrial research laboratories with such practical consequences as the development of the new amplifying device, the transistor. The techniques developed by geologists and geophysicists to study the earth had very rapid commercial application, principally by the petroleum industry. Routine procedures of oil prospecting made use of seismological, geomagnetic and gravity surveys. The high-pressure techniques of the physicist and petrologist were adopted for the commercial synthesis of industrial diamonds.

The discoveries made by nuclear physicists during the 1930s had enormous practical consequences. The work on artificial radioactivity in 1934 led directly to the discovery of nuclear fission in 1938 which in turn led almost immediately to the development of nuclear weapons, and during the post-war period to the further development of reactors for the production of power and unlimited supplies of artificial radioactive isotopes which could be put to countless industrial and medical uses.

The fundamental scientific work leading to the later type of nuclear weapon, the thermonuclear or hydrogen bomb, was recognized as having potentially more practical importance than all the previous applications of basic science to industrial purposes. The rise of modern industry had been at

the expense of an ever-dwindling supply of fossil fuels. The use of uranium fission could extend the available energy sources a few centuries, but eventually the sources of uranium, like those of coal and petroleum, would become exhausted. However, the development of thermonuclear power using the water of the oceans as a fuel would provide an inexhaustible source of power for the service of man. At mid-century, scientists in Britain, the USSR and the USA were working intensively on this problem, recognizing that if the necessary thermonuclear reactors could be designed and built, one of the gravest threats to the long-term survival of an advanced industrial civilization would be overcome.

The conscious exploitation of basic science by industry was in its early stages. Before the second world war it was rare for industrial firms to employ physicists and applied mathematicians; their technical personnel had been trained almost exclusively in engineering. In the post-war years industries were adding to their technical staffs men who were familiar with the fundamentals of the modern theory of matter, in addition to those trained in the more well-established engineering techniques. While research in industrial laboratories continued to be oriented toward the production of usable products, the approach was at a more fundamental level than in the past, and the relationship between basic science and technology was becoming ever closer.[11, 12] (Pl. 6.)

NOTES TO CHAPTER VIII

1. Doctor of Physical and Mathematical Sciences E. I. Adirovich writes that Chapter VIII suffers from the following grave shortcomings: (1) the entire physics of the twentieth century is reduced to microphysics, but at the same time there is neither a proper exposition of the fundamentals of the theory of relativity, nor a proper analysis of its role in cosmogony, field theory, or the physics of elementary particles; (2) only a brief and superficial exposition is given of such important branches of physics as the theory of solids, the physics of low temperatures, semi-conductor electronics, and others; (3) no information is given about the achievements of Soviet physics.
2. Doctor of Physical and Mathematical Sciences E. I. Adirovich writes that in addition to Lavoisier and Dalton mention should be made of Lomonosov and Proust.
3. Doctor of Physical and Mathematical Sciences E. I. Adirovich points out that it would be wrong not to mention at this point H. Moseley. Moseley was one of the scientists who fell victim to the first World War.
4. Professor Khristo Khristov, Member of the Bulgarian Academy of Sciences, writes: The fundamental idea of quantum theory is given in a very simplified form. The remarks in the text could apply to any classical static theory. It should be noted that quantum mechanics rejects the classical view that the co-ordinates and impulse of each particle of matter have at each moment objectively fully determined values (which we can either know or not), and as a result there is a new definition of the very concept of the nature of a particle, which is now determined by its wave function. This definition of the nature of matter is just as determinist as that given by the classical theory, because a wave equation is of the first sequence in regard to derivative time.
5. *The Author-Editors stress that* within the classical concept of determinacy, *the statements in the text concerning the quantum theory could not apply to any classical static theory.*

6. Doctor of Physical and Mathematical Sciences E. I. Adirovich writes that the reduction of the chemical bond to 'exchange forces' will not explain anything to the reader. The essence of the chemical bond in quantum mechanics can be fully explained by means of the Pauli principle and an examination of the nature of a united atom and disunited atoms.

7. Doctor of Physical and Mathematical Sciences E. I. Adirovich thinks that the question of the content in quantum mechanics of Mendeleyev's periodic law—so important both in science and in everyday life—is set forth too summarily and in language too specialized for the general reader.

8. Doctor of Physical and Mathematical Sciences E. I. Adirovich says that it should be pointed out that Soviet scholars were the first to photograph the centre of the galaxy.

9. Doctor of Physical and Mathematical Sciences E. I. Adirovich writes that A. M. Belopolsky was the first to prove the applicability of the Doppler effect to light. Mention should also be made of the work of Academician G. A. Shayn, who developed a method for determining the velocity of the axial rotation of stars, from the form of their spectral lines, which was of great importance for cosmogony.

10. Academician V. A. Ambartsumyan underlines that only one conclusion is possible: that the metagalaxy is expanding. Idealist philosophers see in this proof that the universe began to expand from a single point, i.e. as confirmation of religious views that there was a single act of creation.

    In actual fact there is nothing supernatural about the process of expansion of the galactic systems. In the universe scientists see various systems of heavenly bodies which are distinguished from one another by the nature of the movements within them. Some of them are extremely stable, others are not. An example of a very stable system is the one revolving around the sun. The earth has already made milliards of revolutions around its sun, and in all probability it, as well as the other planets, will remain a member of the solar system for a long time to come. A similarly high degree of stability is found in the double stars, i.e. systems consisting of two suns. However, the so-called aggregations of stars, containing hundreds or thousands of stars, are far less stable. Calculations have shown that each star can only make a few revolutions around the centre of gravity of the aggregation. In the larger stellar systems this instability is still more marked. The Soviet scientist B. Vorontsov-Velyaminov has published a magnificent atlas of dual and multiple galaxies, from which the instability of such large stellar systems is clearly visible.

    Expecially interesting are the data relating to individual aggregations of galaxies in the metagalaxy. It has been shown that many of them are disintegrating. This is apparent from the fact that the velocities of individual galaxies in such aggregations are very great in relation to one another. In the view of many astronomers this means that when the aggregation appeared the galaxies received such high velocities that the forces of Newtonian attraction were from the very beginning too weak to hold them back. In just the same way the metagalaxy, too, is expanding because its individual members received very high velocities at the moment of its formation. Thus science proves that there is nothing supernatural in the fact that the metagalaxy is expanding. Moreover, Einstein's general theory of gravity gives us a theoretical foundation for the proposition that very large systems are unstable on account of the very character of Einstein's law of gravity.

11. In spite of the fact that the Author-Editors have presented a series of chapters on the application of the physical, biological, and social sciences, following discussions of the major scientific developments in each of these fields, they have been criticized for not showing adequately the interaction between science and other aspects of the culture. Professor Herbert B. Callen writes with respect to the physical sciences: 'I would have expected the account to stress the interrelationship between science and culture. Many accounts have been given of recent scientific developments, and many of cultural evolution, but seldom has the strong interaction between these two been explored.' Professor S. N. Eisenhardt remarks with respect to the chapters on the application of the social sciences (Chapters XVII to XIX): 'Not enough emphasis has been given to the utilization of social science in various applied fields . . . and to the ways in which

social science services become institutionalized as professional service roles in different fields, such as industry, agriculture, settlement, counselling, etc.'

Professor E. N. Anderson comments that these criticisms serve to underline the immense difficulty of tracing the multitudinous and vastly complex interrelations between science and other elements in modern society.

12. *The Author-Editors limited themselves to general treatments of the application of the physical, biological, and social sciences after attempting to find a more precise way to identify significant specific relationships. For example, the authors consulted several industrial specialists in an effort to determine what had been the most important scientific 'breakthroughs' in the technology of their industries. The specialists countered with the question, 'Which "breakthrough"? The basic scientific discovery, the recognition of what the discovery could mean, the actual invention, the experimental stage of innovation, or the later, perhaps minor, modification which made the use of the invention economically feasible?' By the time that the authors had traced the process for a single feature of the technology of one industry, it was apparent that only very general relationships could be treated in a volume of history such as this.*

CHAPTER IX

INDUSTRIAL PRODUCTION

I. INTRODUCTION: THE SPREAD OF TECHNOLOGY

THE technological development of the twentieth century followed a common course throughout the world, despite difference in levels of development and in social institutions. In a broad sense, technology like science constituted a common pool of knowledge, available to all who commanded the understanding, skill and resources to make use of it. Engineers throughout the world shared common procedures for applying basic scientific knowledge to problems of production and within their respective fields of specialization could talk a common language; trade secrets were only a very minor deterrent. Workers in steel, textile, automobile or chemical factories could quickly find themselves at home in plants of the same industry wherever they might go.

The common aspects of twentieth-century technology were derived from its essentially scientific base, although the extent to which advancing science was put directly into practice varied markedly from one field to another. Until the advent of the scientific age science and technology had followed largely independent paths, the one academic, in the hands of scholars, the other empirical, in the hands of craftsmen. Science had been an area of speculation and study through which man might enhance his understanding of his world; the craftsman had generally drawn his principles as well as his techniques from tradition and experience, not from a body of knowledge most of which lay far outside his ken. But from the beginning of modern industry the gap between science and technology had been gradually narrowed, and in the twentieth century it was bridged by a large and rapidly growing corps of engineers, applied scientists and technicians, as inventions based on scientific discovery overshadowed those arrived at by trial and error.

The great mass of technology that was derived from the physical sciences rested on Newtonian principles and on the basic discoveries in physics, chemistry, astronomy or geology that had already been made before the end of the nineteenth century. By the middle of the century, however, the new scientific discoveries were becoming the bases for major technological advances, especially in the fields of electronics and the use of atomic energy.

It would be impossible to detail the innumerable technical developments of importance during the years under review. The host of discoveries, inventions and new arrangements that affected industry, transport, communication, warfare and all aspects of daily life were cumulative and interrelated. Often the

steps in their development were obscure and comprehensible only to those who understood related processes. Even the effort to identify key developments leads to the dilemma of what to single out from the continuum of invention and innovation—an initial concept, a first discovery, a later discovery making the first one technically usable, a third making it economically feasible or a fourth converting a process of limited applicability into one of widespread usefulness. Inventions and techniques which at the time of their development appeared of minor significance later proved to be among the key events. At any given time only those whose impact had already been felt could be identified with assurance.

The chapters which follow therefore confine themselves to the common features and major trends that run through the technological developments of these years and the changes in way of life which the new technology made possible or imposed. An examination of these trends, and of their most advanced forms, yields a view of the direction in which mankind was moving, but not a realistic picture of the uneven actuality at any time. If the direction of trend is taken for a description of actuality, the account may seem exaggerated, unreal or idealized. Yet it is not irrelevant to contemplate these same trends in global terms, for the extension of the most advanced technology to areas still using primitive methods was already in process. In the rapidly moving world of the twentieth century it was not at all fantastic to consider the face of India if its *per capita* supply of motor vehicles should even begin to approach that of the United States, or the drain on world resources if China should utilize paper at a *per capita* rate approaching that of Canada, or the effect of using the uranium mines in the Congo to provide a vast source of energy to its African neighbours.

In considering the main trends, however, and recognizing many of them as irreversible and bearers of permanent changes in the life of mankind, it is important not to overlook lesser, sometimes partly counterbalancing tendencies. In the main, for example, twentieth-century developments were toward mass production. But the very cumbersomeness and complexity of mass-production processes left the door open for small, specialized operations which had the flexibility that mass production sacrificed for the economy of repetitive operations. In the mid-twentieth century, countries or segments of industries with a tradition of quality and specialization, as in France and Switzerland, were exploiting high-level technology in the latter manner.

The mounting drive for the development and introduction of new techniques was world-wide, gathering momentum in industrial centres and catching up the less developed areas in its sweep. But the drive was stronger in some areas than in others and, although the general tendency was for the pace of technical advance to accelerate, pressures were more intense and conditions more favourable in some periods than in others.

In general the most advanced techniques of industrial production, transport, communication and warfare were to be found in the countries of advanced

scientific and industrial development. In the nineteenth century these had been the countries of Europe, especially Great Britain and Germany, and they continued to be centres of innovation. By the opening of the twentieth century the United States was taking the lead technologically and it remained in the vanguard in many fields throughout the first half of the century. By mid-century the USSR was coming to the fore, especially in some lines such as the long-distance transmission of high-voltage electric current and the propulsion and guidance of objects in space.[1, 2]

The most advanced technology was not however always to be found in the most fully developed areas. Although the process of technological advance was cumulative, each new development providing the momentum for others, existing techniques could act as a block as well as a stimulus, for they represented a large investment of capital and a vested interest for both owners and workers. Just as the factory system had developed more vigorously in England in the eighteenth century than in France where handicraft industries were more highly developed, and as German industry had overcome its late start by introducing the most recent designs while Britain was burdened by old equipment, so in the twentieth century some of the most up-to-date methods were to be found in newly industrialized sectors of advanced industrial countries or in plants based on the most advanced foreign models in countries in early stages of industrial development. The absence of antiquated equipment and the freedom from vested interests thus at least partly balanced the advantage of prior development.

Yet although underdeveloped areas could and did install modern plants, they remained mere borrowers, dependent upon technical developments elsewhere until they had the scientific, engineering, managerial, vocational and capital resources to carry forward the process of invention and innovation. It was the presence of a technological complex rather than of specific examples of advanced technology which distinguished the industrially developed from the newly developing areas.

Many factors acted as a stimulus to technological advance. Pressures to substitute mechanical for human labour were great wherever there was a relative shortage of manpower or high wages, a chronic situation in the United States and one of the reasons for its high level of mechanization. Such pressures were intensified by national drives which identified national progress or survival with technical advance.[3] Wartime needs brought many practical applications of existing knowledge which might otherwise have taken decades to work out. German technical development was stimulated by the Nazi effort to achieve autarchy and again in the intensive drive to re-establish the German economy after the defeat and destruction of the second world war. The revolutionary society of the USSR staked its survival and its future on intensive technological progress and spared no effort to introduce the highest degree of mechanization attainable throughout industry, agriculture and all parts of the country. Even in the Chinese People's Republic

where manpower was abundant, the national drive to remake Chinese society and re-establish China's position as a world power included efforts to use and improve the most advanced productive methods, as well as to use modest devices to supplant primitive practices, such as the wheelbarrow to replace the carrying pole.

Incentives for technical development, which were generally strong in time of prosperity when demand for the products of industry was high, investment funds were available and the opportunities for the profitable exploitation of new techniques appeared ample, were weak in time of depression when opportunities seemed poor and manpower was unemployed. They were weak where vested interests in older processes were strong, where funds for investment were scarce, where management was conservative and where the institutional structure of the society obstructed or was unfavourable to technical change. They were weak where there was an abundant supply of cheap labour.

The technology of the production process itself, however, often dictated the choice between machine and worker even when labour was plentiful. Oil companies built the same types of installations in Latin America, the Middle East or south-east Asia where labour was cheap as they did on the east coast of the United States where it was among the highest priced in the world. As machine technology developed, the alternative of using cheap labour tended to become less attractive economically and the presence of available workers did not slow down the mechanization process. This was one of the dilemmas which faced the newly industrializing countries as they turned to industry to provide a basis for raising the levels of living of their people, yet could not employ the very ones most in need of work.

A further difficulty faced both the newly industrializing and the smaller industrialized countries. The processes of research, invention and application tended to become so costly that only the biggest nations with the most abundant resources in capital and highly specialized technicians could afford to finance and manage them. This difficulty was most conspicuous in respect to the development and use of atomic power.

Yet although advancing technology, paced by advancing science, carried much of its own momentum, institutional factors arising from non-technical sources affected the application of science and technology to industry, transport, communication and warfare. For the most part institutional factors tended increasingly to favour technological progress.

Industrial production in the twentieth century depended upon organization and upon techniques which made large-scale complex organization possible. Without rapid and reliable transport and communication, without effective record keeping, without the organizational structure and operating processes to make use of the technical potential, and without the political and social systems which would permit and sustain the myriad transactions involved, the effort to put technological advances into practice could only have broken down

in chaos and confusion. The social inventions of the twentieth century were no less essential for the application of scientific knowledge to material production than were the more strictly physical aspects. Management was as important a technical development as electronics.

Legal institutions, taxation and public policies provided a framework within which the momentum of technical change worked itself out. Access to materials depended upon ownership rights and royalty systems as well as on the advancing technology for prospecting and extraction; tax systems could hold back exploitation or encourage wasteful methods. Throughout the period most institutional arrangements favoured the exploiter of material resources and few serious obstacles stood in the way of the use of materials as fast as technology permitted. A growing movement for conservation of resources placed some restraint on wasteful practices; more effective were the technical developments themselves that permitted better and more complete use. Where subsoil resources were sought by foreign enterprises, as was the case for a large proportion of the oil reserves and for minerals in Central and South America, Asia and Africa, the terms of their exploitation became an issue of national sovereignty and international relations. But the widespread insistence on national rights over local resources merely effected a division of profits more favourable to the government of the country where resources were located; it had little effect on the actual use of materials or the manner of their technical exploitation.

Public policy entered into the availability and cost of energy to an increasing degree as an ever-growing proportion of industrial power was supplied in the form of electricity. Not only was the available supply of electric power directly affected by the public undertaking of great hydro-electric projects, valley developments and, latterly, the beginning use of atomic energy; the transmission of electric power and its cost was everywhere subject to public control, by ownership or regulation, and to policies which determined where and how it would be supplied. The tendency was to regard the provision of cheap power as a public investment in national and local development and to favour projects and policies tending to expand the supply and lower the cost.

Patent systems designed to encourage the invention of new processes were well established in Europe and America before the development of modern industry. How far this device to secure to the inventor the proceeds from his invention actually stimulated technological advance is not clear, for it could also act as a deterrent to innovation. In some industries at least, patent guarantees attracted the investment of capital in new processes to which existing enterprises were blind or which they feared might undercut their established position. In the development of radio, for example, independent capitalists in Britain and the United States backed companies formed to exploit Marconi's wireless patents and, later, the patents on receiving devices and tubes, while the well-established telephone, telegraph and electrical manufacturing companies showed no interest in this new field. Elsewhere patent systems were

accused of facilitating monopoly and examples of the buying up of patent rights in order to suppress rival inventions were not unknown.

In any case the importance of patents as a stimulus to invention and innovation declined as industrial and governmental research laboratories rather than the lone inventor became the principal sources of technical innovation. Even where patents existed there was some tendency to forgo their use; automobile manufacturers in the United States, for example, adopted a system of cross-licensing of all patents among members of the automotive manufacturers' association, and the entire American industry developed on this basis; the most radical innovation in electronics after the vacuum tube, the transistor, was made freely available by its inventors and passed rapidly into use. The USSR and other communist countries discarded patents on the principle that inventions which might increase productivity must be the property of all the people, although they offered various rewards to encourage invention.

The factor most subject to institutional rather than purely technological influences was the utilization of labour, which came to be hedged about in all industrialized or industrializing countries by minimum standards and requirements based on human rather than purely technological considerations. Throughout the industrial world, and increasingly in industrializing countries as well, limitations with respect to such matters as child labour, hours of labour, working conditions, wages and social security took similar forms, along lines expressed in the conventions formulated by the International Labour Organization. At the same time technological advance itself made it possible to think in terms of limitations on hours of work and minimum levels of income and security for all.[4]

In a broad sense the total milieu in the industrial countries favoured technological development. In western Europe the old structure of custom, feudal privilege and craft regulation had largely broken down by the beginning of the century. In the United States, Canada, Australia and New Zealand it had never existed. In the USSR it was destroyed by revolution.

Environments strongly favourable to technical development existed in many countries. The spirit of individual and group enterprise and of innovation received strong cultural sanction in the United States; German science and technology paced the world in many lines; Britain retained its scientific and technical leadership in others. Japan's national programme of industrialization took the form of copying and adapting new industrial techniques as fast as they were developed elsewhere. The USSR oriented its highly centralized and directed society toward production goals and threw the full weight of its support to technical education and research. In non-industrial countries where the milieu favoured the perpetuation of traditional methods rather than innovation and change, leaders recognized that programmes designed to provide a new technical base for rising living standards could only succeed as part of a broad cultural reorientation.[5]

On a yet more fundamental level the scientific spirit itself was the most

essential ingredient in the twentieth-century technological development. The whole structure of modern technical advance rested on a rational spirit of free inquiry. To the extent that this spirit dominated, the conditions existed for the rapid growth of scientifically based technology and the transformation of society at its hands; only where this spirit penetrated could any but a limited, imitative development be anticipated. Man's growing command over nature in the twentieth century thus involved a three-way relationship between science, technology and the social milieu, each producing, supporting and depending on the other.

As applied to industrial production, modern technology involved the discovery and creation of new materials and new uses for old, the harnessing and use of energy in new forms and from new sources, the designing of new machines and new organization for industrial plants, the development of an increasingly capable labour force and its more productive use, and the evolution of management techniques.

During the first fifty years of the century one single industrial country, the United States, used more of the earth's minerals than had been withdrawn from the earth's crust for man's use in all preceding history. The *per capita* amount of energy harnessed for man's use tripled for the world at large and more than quadrupled for the country with the highest energy consumption in 1950. Mechanical power, substituted for human effort, first replaced physical labour for lifting, hauling, pushing, twisting and pressing; then it replaced manual skills as craft processes were analysed into their component steps and machines were devised to perform each process; by mid-century electronic computing and control devices able to observe, select, calculate and command more accurately and swiftly than the human eye and mind were beginning to be used to perform many of the steps in the managerial process. Mechanization thus altered successively the nature of work and the requirements which men must meet in order to become productive members of society.

The stream of products that emerged from mines, mills and factories entered the standard of living and transformed the way of life of the world's industrial countries. The productivity of twentieth-century industry not only made possible much release from toil but it enabled those who, throughout the ages, had sustained civilization by their labour but had shared few of its fruits to become partakers as well as producers.[6]

Every industry as it grew in size and complexity depended on the presence of countless subsidiary industries providing its materials, gauges, parts or machines. It depended on a trained labour supply, able to operate machines and keep them in repair; often it required mechanics ready to repair its products after they reached the consumers. It depended on a sufficient body of purchasers able and willing to buy its output, and upon the means of communication with this market and transport to it, as well as communication with and transport from its sources of supply. It depended too on financial

resources, on legal protection and regulation of its dealings, on the physical facilities such as water, power, streets and houses required for its operations and for the living of its employees, on the social resources which its workers required. It depended in short on a whole industrial complex of which industry itself, though it was the core, was only one interrelated part.

The economic institutions which provided a framework for industrial activities were elaborated in the capitalist countries as industrial development required, and were carried to the distant parts of the world to which industry penetrated. An alternate set of institutions, facilitating the same essential industrial processes, were developed within the communist orbit. Economic motivations—work, production, a high standard of living—were sanctioned by the cultures of the countries where the industrial complex flourished during these years.*

II. MATERIALS

Basic to industrial development in the twentieth century was the growing ability to use more and more kinds of materials to serve man's needs and wants. In one sense twentieth-century technology was the greatest user of resources that the world had known; in another sense it was the greatest creator, for it transformed one after another of the elements in the land, sea and air into forms which man could use.

In the middle of the twentieth century a United Nations Conference on the Conservation and Utilization of Resources held at Lake Success, New York, in 1949 opened with a review of the world's critical shortages in minerals, fuel and energy, forest resources and food. Simultaneously the president of the United States appointed a Materials Policy Commission to answer a question which would have seemed absurd to that resource-rich country fifty years before: has the United States the material means to sustain its civilization?

Both groups were aroused by the possibility that economically usable supplies of many materials on which industrialization had hitherto rested might become exhausted. Estimates of known or suspected supplies of copper, tin, zinc and lead, for example, indicated that, at the rate of world consumption at mid-century, those which could be exploited by current methods at current costs would be used up well before the end of the twentieth century. Moreover, since the rate of consumption in the industrial countries was many times that of the rest of the world and population was expanding steadily, the rate of consumption could be expected to increase as industrialization spread. If the non-industrialized part of the world should reach the European rate of consumption, estimated resources of these particular metals would be exhausted in ten to twenty years. Yet the United States was already using the principal minerals at three to five times the European *per capita* rate and petroleum seventeen times as fast.

At the same time twentieth-century technology expanded the world's

* See Chapter XXI, Economic Institutions.

industrial resource base in a number of ways: by making possible the discovery, extraction, transport and use of unknown, inaccessible or low-grade materials which could not be used before; by so refining, combining and treating minerals as to make a given supply do much more work more effectively; by creating new materials from common substances through chemical processes and by improving ways of preserving materials and re-using them.

Early industrial development had depended chiefly on the nearby, readily exploitable and richest veins of coal, iron and other minerals. The iron and coal of Lorraine and the Ruhr, the British 'black country', and the fields in the eastern United States accounted in 1900 for as much as four-fifths of the world's output of coal and three-fifths of its iron ore. Less bulky minerals which could stand higher transport costs had been sought out in many parts of the world and drawn to industrial centres from their richest sources—manganese from Russia and Brazil, tungsten from China, nitrate from Chile, tin from Malaya, nickel from Canada, mercury from Spain, zinc from the United States, silver from Mexico, gold from South Africa. With the methods of 1900 and the ratio of demand to resources, only the best and most accessible seams of coal were mined and the best grades of ore exploited, while the smelting process discarded as waste many materials that later methods were able to recover and use. Most mineral deposits were discovered by prospectors who penetrated to an area on foot or horse and used simple tools to test outcroppings that looked promising. The great bulk of the earth's minerals remained unexplored.

From the time of the first world war newly developed geophysical methods of prospecting made it possible to detect subsurface minerals in areas which could not have been explored by old methods without great difficulty and cost. Large sections of the United States, Canada, Sweden, South Africa and Russia and several parts of Latin America were surveyed, and areas likely to repay exploratory drilling were identified by the use of devices which registered and recorded variations in the magnetic susceptibility and specific gravity of rock formations and differences in the electric conductivity and elasticity of the earth's crust. These methods so reduced the cost that they revolutionized the scope of mineral exploration and brought to light vast new oil and ore reserves in the years before the second world war. Developments in electronics and aviation during that war effected a second revolution in prospecting methods. Geophysical exploration from the air could be carried on in a fiftieth to a two-hundredth of the time required for ground surveys and could be done at a tenth to a twentieth of the cost even with expensive equipment.

In spite of all these improvements in prospecting methods great areas of the earth's surface in South America, Africa, northern Canada, Asia, Australia and Antarctica still remained unexplored at mid-century and no reliable estimates could be made of the world's total mineral reserves. The means for such exploration were at hand, however, and the undertakings of the Inter-

national Geophysical Year (1957–58) sought to expand the world's knowledge of its hitherto undetected reserves.

Technical developments in transport, mining and the recovery of metal from ore made the exploitation of distant and difficult sources not only physically possible but economically feasible. By the middle of the century ore was being mined far into the Arctic, high in the Andes mountains and deep in the jungles of South America and Africa, and oil was being pumped from under the desert, the jungle and the sea. Nickel was being mined on the Arctic shores, iron and titanium in sub-Arctic Labrador, and Canadian uranium was being carried 500 miles by inland waterways open only between June and September; jungles, disease and distance had been overcome to open the great Northern Rhodesia copper belt, the lead, zinc and copper mines in remote sections of south-west Africa, the uranium and copper deposits of the Belgian Congo, the ironfields of interior Venezuela and Brazil and the ore resources of Siberia and north China. Oil was pumped through pipelines from the Persian Gulf to the Mediterranean, from Texas, USA, to the eastern seaboard and central United States, and across Venezuela.

Mechanization of mine operations changed mining methods and extended the scope of profitable mining. Electricity in underground mines made it possible to replace the miner's pick, to use motors instead of donkeys to drag the loaded cars, to replace the dangerous miner's lamps by electric lighting, and to use powerful blowers forcing refrigerated air to ventilate much deeper diggings. Miners' productivity increased sharply even where the richer seams had already been worked and the poorer or less accessible were being exploited. In coal-mining in the United States, for example, output per worker more than doubled in the first half of the twentieth century although the working week was cut almost in half. By 1957, 85 per cent of the cutting and loading was done mechanically and 59 per cent of the cleaning, whereas in 1900 only a quarter of the cutting and none of the loading or cleaning had been mechanized. Towards the middle of the century continuous, automatic machine cutting, loading and transporting of coal and ore from the face to the pit mouth was beginning to eliminate blasting to dislodge the material being mined.

Heavy equipment for moving earth—the giant bulldozer and steam shovel—introduced strip mining where ore or coal was not too far below the surface, removing the earth cover and scooping out the material with a minimum of time and labour. Strip mining in the United States, which began shortly after 1920, accounted for nearly a quarter of that country's coal-mining at mid-century; in the USSR it increased from 4 per cent in 1940 to 19 per cent in 1957. The use of flame for boring into rock too hard to drill opened up very large reserves of taconite which could not be worked for its iron content by traditional methods. Drilling for oil, meanwhile, was reaching greater and greater depths as new metal alloys increased the cutting power of the drills.

Developments in metallurgy played a major part in expanding usable

resources, for they made it possible to recover metal from lower grades of ore, to extract a larger proportion of the metal content, to separate out and refine to much greater purity the several minerals contained in each ore body, and to combine or treat metals so as to derive materials with new properties. The froth-flotation process proved much more efficient than older methods in separating out and concentrating a large range of ores; by placing pulverized ore in a succession of chemical solutions each type of mineral could be floated out in the froth of its appropriate chemical. Electrolytic refining gave greatly increased purity and made it possible to recover many rare metals, such as cobalt and platinum from the refining of copper and nickel, by passing an electric current through appropriate chemical solutions in order to deposit one or another of the component elements.

With these new processes, slag piles surrounding old smelters became virtual mines in themselves from which formerly wasted products were extracted, and little remained to be cast on to the slag heaps of new smelters except the ubiquitous silicon, whose possibilities were only beginning to be exploited at mid-century. Introduction of dust precipitators and collectors into the smoke-stacks of smelters, together with devices for capturing and converting smelter gases, not only recovered large quantities of materials that were formerly wasted but protected the people and vegetation of the surrounding area from harmful dust and fumes.

Although ore once withdrawn from the earth cannot be replaced, its initial use in industry did not necessarily mean its destruction as a future resource, for the re-use of the material in discarded products offered a source upon which industry could draw. As industrial output accumulated over the years dumps, especially those for old cars, junk yards, and demolished buildings contained a large metal supply. With the improved methods of recovery in use at mid-century it was estimated that 60–65 per cent of iron, copper and lead, 40 per cent of aluminium, and 20–25 per cent of tin, nickel and zinc could be recovered and re-used after their initial fabrication. Scrap already provided nearly half of the iron, over a third of the lead, copper and aluminium and a quarter of the zinc going into the furnaces in Great Britain and the United States. While a substantial proportion of this was waste produced in the process of manufacture itself, such as the remains of steel sheets after forms had been stamped out, and thus did not provide a supplement to newly mined ore, much was old scrap from discarded objects of manufacture. As the stock of metals in use grew constantly, so did the quantity returning as old scrap, and the proportion of the total supply coming from this source tended to increase over the years.

New methods of extraction made available to industry metals which had formerly appeared only in the laboratory. These furnished the basis for an array of special steel alloys and for the substitution of light metals for the materials—iron, simple steel and wood—on which modern industrial development had originally been based. Special steel alloys, hardened or strengthened

or given special properties by admixtures of molybdenum, nickel, chrome, vanadium, cobalt, titanium and other minerals, met a wide variety of specialized needs. Tungsten carbide, developed for general use in the 1920s, lengthened the life of machine tools by twenty-five to a hundred times and greatly increased the speed at which they could be operated or the precision of the finish which could be obtained.

Such special alloys and new metals were essential, for modern industry required materials which would stand up and perform under conditions to which no previous materials had been subjected. Metals used in steam turbines had to withstand pressure of 5,500 lb per square inch and temperatures of 1,150° F, as compared with 170 lb of pressure and 280° F of heat in 1900; aircraft engines had to operate at terrific heat and great speed for many hours, and must not fail. Piping, which was once judged adequate if it allowed no more than a drop or so of leakage per minute, had to be absolutely without leakage when used to carry radioactive materials in atomic installations. The refining of zinc to a purity of 99·9 per cent during the first world war was hailed as an advance, but a transistor required silicon with no more than one part of impurity to a hundred million parts of pure metal.

Where lightness was a consideration aluminium, which had begun to be produced commercially at the opening of the century, became the most extensively used and cheapest metal next to steel. By mid-century it was not only being used as the basis for the aircraft industry and in other places where steel, because of its weight, would not serve, but was being widely substituted for steel and other materials in many types of construction and fabrication and was replacing copper in wire for electrical transmission. From the time of the second world war magnesium began to share the position occupied by aluminium as rapid improvements in its processing lowered its cost and made it economical to take advantage of its extreme lightness and considerable strength.

Both aluminium and magnesium required large amounts of electric current in their production; the rapid growth in their supply and drop in price depended on the expansion of power generation. Raw materials for both were widely distributed, aluminium in small concentrations in most earths and magnesium in sea-water. Up to mid-century aluminium was being manufactured only from rich bauxite deposits containing 50–60 per cent aluminium oxide, located chiefly in southern France and Italy, British and Dutch Guiana, the United States, Hungary, the USSR, Jamaica and Ghana. Magnesium however had begun to be extracted from sea-water in 1937 by a procedure which had been regarded as fantastic when it was proposed in the early part of the twentieth century, and at mid-century a large part of the world supply was coming from that source.

On the heels of magnesium another widely distributed substance, titanium, came to be recognized as a new metal with great possibilities, when a satisfactory process for making it in a pure and usable form was developed toward

the middle of the century. New techniques for smelting iron from titano-magnetic rock not previously regarded as a source for either iron or titanium produced a slag containing an ample workable supply of titanium and helped to reduce its cost. As a metal both lighter and stronger than most steels and extremely resistant to heat and corrosion, titanium was used in alloys for such purposes as jet engines even while its cost was still high. An even more costly metal, zirconium, was being used in nuclear installations, primarily because of its resistance to corrosion and acid. The most abundant mineral in the earth's crust, silicon, was also beginning to enter into industry in silicone plastics and, experimentally, in other forms.

As techniques were improved for separating out the components of a given piece of rock and more was known about the values and uses of a wider and wider range of minerals, the exhaustion of traditional resources seemed less of a threat to continued industrial growth. Since ordinary granite rocks contain most minerals in some proportion, it was technically possible to take practically any rock which might be at hand, pulverize or dissolve it, and sort out the component elements for use in whatever combination local industry might require. Sea-water, already yielding magnesium, could be utilized for others of the many minerals which it contained. Air had already proved to be a source for nitrogen used in fertilizers and might be tapped for other elements. To the extent that these possibilities might be economically realizable, a virtually unlimited material basis would be available for industry in practically any part of the world which possessed the necessary technical knowledge, equipment and power.

One of the most spectacular and revolutionary contributions of technology to the supply of industrial materials was the creation of new substances, known generally as plastics, either in imitation of natural products or to provide something which had no counterpart in nature but which possessed properties desired for a particular use. Using chiefly hydrocarbons which could be derived from many sources—coal, petroleum, coal tar, cellulose from wood pulp or sugar-cane waste—the chemical industry learned how to put together enormously complex chains of atoms by a process known as polymerization to produce tough fibres, sheets or moulded forms. Since the variety and complexity of the chains which could be created was almost unlimited, it became possible to introduce many different properties, both by the chemical elements included and by the process of treatment. Additional possibilities were being introduced by the use of silicones instead of hydrocarbons as a base.

The prototypes of plastics had been developed before the turn of the century in the form of celluloid and bakelite. The first of the synthetic fibres, artificial silk or rayon, was in use in the 1890s and its manufacture by various methods became well established in the first two decades of the twentieth century. In the 1930s a number of new plastic materials began to be produced commercially, especially in Germany where they served as *ersatz* or substitute products for natural fibres and other materials in short supply.

The full potentialities of plastics, however, only began to be envisaged during and after the second world war with improvements in their quality. Such critical war materials as nylon for parachutes and synthetic rubber to keep motor transport in operation when natural resources of rubber were cut off emphasized the importance of synthetic products. Plastics manufacturers turned from efforts to devise substitutes as good as some natural product to the development of materials with characteristics which natural products lacked, and they supplied an enormous range of fibres, sheets, shapes, paints, and substances which could be mixed with other material such as wood or glass to give them new properties.

The development of plastics was paralleled in the production of glass, a material also based on a resource, sand, which was unlimited and readily accessible. Although glass-making was a very old art, glass became a cheap material in general use only after a machine process for bottle blowing was introduced at the beginning of the twentieth century. In the course of these years glass became a highly versatile material as ways were developed to preserve its imperviousness to corrosion and its transparence while overcoming its brittleness and fragility. Types of glass were developed of such hardness as to be bullet-proof, of such heat resistance as to be used in laboratory equipment subjected to intense heat, of sufficient strength for building blocks and wall panels, and of a flexibility which could be drawn into fine fibres and woven into fabrics. Its transparent qualities could be so controlled as to let through or exclude either ultra-violet or infra-red rays, or to be transparent from one side and opaque from the other. In combination with plastics, fibre glass was moulded into boats, car bodies, wall panels and translucent roofs that were strong, light and of low cost.

Concrete had begun to supplement brick, stone and wood as a structural material in the second half of the nineteenth century; during the twentieth century it became one of the most widely used materials for the construction of industrial plants and for most large urban buildings, bridges and main roads. Although it had the advantage of being made from plentiful material found in many localities and of being easy to handle, the large amount of cement and reinforcing steel required for strength made this a heavy building material, eminently suited for foundations but bulky when used for superstructures and roofs. New concretes, made by mixing in such things as sawdust, volcanic ash and certain lightweight minerals or by adding chemicals, were lighter and more versatile. Panels for roofs and partitions could be prefabricated, preinsulated and transported with relative ease. Prestressing of concrete, to give strength to beams at the place where strain was greatest, substantially reduced the amount of cement used and achieved the same strength with only a fraction of the usual reinforcing material. Other materials such as gypsum, sugar-cane waste or asbestos were pressed and chemically bound into sheets for use in building construction, and insulating materials were made from glass fibre or other non-conductors of

heat in order to reduce the thickness of wall required for warmth or to conserve heat. (Pl. 11a.)

Although the industrial development of the twentieth century rested primarily on the use of metals, plastics, cement and glass, wood continued to serve many of its old purposes and, in combination with plastics or subjected to chemical treatment, was put to new uses. New techniques gave wood new properties and extended available resources by utilizing lower grades and much of what had been discarded as waste. At mid-century high consumption of wood was associated with a high degree of industrialization, as was evidenced in the fact that the *per capita* consumption of timber, lumber and plywood in North America was five times that of Central and South America, while in Europe, with very much more limited forest resources, it was some 16 per cent greater.

One of the largest consumers of wood was the paper industry. New processes were designed for making cheaply the enormous volume of newsprint consumed in the countries where literacy was general and for many types of strong, sturdy or absorbent papers. They converted paper from a scarce item to be cherished and re-used to a cheap, plentiful material produced with the idea that much of it would be destroyed. Cartons and corrugated boxes took the place of wood, metal and cloth containers; disposable tissues, towels, napkins and paper cups offered cleanliness and convenience and reduced the transmission of germs, especially in public drinking and eating places and washrooms. These many uses raised the *per capita* consumption of wood pulp in the principal paper-consuming countries, the United States and Canada, to five times that of European countries other than the Scandinavian, and twenty-five to a hundred times that of most of the rest of the world.

While new techniques enabled the paper industry to use quick-growing types of trees, the enormous expansion in demand for paper constituted a mounting drain on forest resources, and together with industrial demand continued to press on the world's wood supply. With a long history of forest conservation, timber in most European forests was felled during much of the twentieth century at a rate which balanced growth, but wartime demands and requirements for post-war reconstruction upset the balance and led to cutting in excess of the rate of growth. In North America, where virgin forests had seemed inexhaustible, interest in forest conservation began to be aroused only in the first decade of the twentieth century, scientific forestry practices were slow to take hold, and at mid-century cutting was exceeding annual growth by as much as 50 per cent.*

The use of all these materials was not only dependent on technological developments but also on the conditions under which they were made available to those who might exploit them.

Control over mineral resources and their exploitation at the opening of the century was vested generally in the owners of surface land; it was on this

* See Chapter XIV, section on Forestry

basis that the coal and iron resources which sustained nineteenth-century industrialization had been mined. Since the size of landholdings, the interests of owners and the terms on which they were willing to lease the right to mine below their soil did not necessarily coincide with the most rational and technically sound methods of extraction, mining was often uneconomic and wasteful, as for instance where a multitude of small units brought out only the best from each spot, leaving the rest of the seams difficult or impossible to work. Royalties to landowners were often a heavy charge against mining operations. Where minerals lay below the public domain, as in much of the United States, Canada, Australia, and in some parts of South Africa, or in areas claimed by various colonial governments, the system known as free mining prevailed. Under this system a prospector could exploit the minerals which he discovered if he met the established requirements for registering his claim, developing it within a specified period and making the prescribed payments to the government.

In the case of petroleum the fact that a single underground pool could be tapped at many points and drained through any one of the wells which reached it led to highly competitive and wasteful drilling. When oil was struck in an area where there were many surface-owners, the original driller quickly sunk as many wells as he could in order to pump oil out fast, while his neighbours rushed to drill on their land in order to pump out their share before it was gone. Forests of derricks in the oilfields of Rumania, Mexico and the United States bore witness to the results of the surface-owner's right to drill and the driller's right to pump all that he could draw. This system proved so wasteful of oil, and so uneconomical in its tendency to glut the market irrationally, that governments intervened to establish controls over the rate at which oil could be withdrawn.[7]

Since many of the mineral and petroleum resources developed in the twentieth century lay in industrially undeveloped areas and were sought by foreign concerns, the terms on which they could be exploited were determined by the relations between the governments of these countries and the foreign oil, steel and mining companies. The companies received concessions from the governments to search and exploit and undertook costly and highly uncertain exploration in the hope of finding rich resources which would yield a high profit in return.[8]

Because of the vital importance of oil and minerals to the development of modern industry and to national security, these resources came increasingly to be regarded as national assets rather than private possessions and governments extended their control over the manner of their exploitation. Mexico and others of the Latin America countries laid claim to all subsoil resources not yet being worked and then extended their claim to those already under concession, sometimes nationalizing the entire industry as in the case of Bolivian tin. These governments and those in the Middle East granted concessions for oil and other minerals on terms which assured that a proportion

of the returns should be paid to them. When terms already granted appeared unsatisfactory they insisted upon and secured larger proportions of the returns, and asserted their right to nationalize the operation on the principle that the resources lying below the earth were the birthright of the political unit beneath whose soil they lay. Mining operations were wholly nationalized in Russia immediately upon the establishment of the Soviet state, and by the communist régimes in the eastern European countries after the second world war. Great Britain nationalized mineral rights before the second world war and took over the entire coal industry after the war. The major part of Holland's coal mines, developed to meet the shortage of the first world war, were state-owned.

Countries dependent on sources outside their borders for supplies of minerals vital to their industry adopted the practice of stockpiling supplies against a possible emergency. In time of war and during years of tension, governments exercised rigid controls over the flow of metals in international trade in the effort to withhold such materials from opponents as well as to assure their own supply.

Although the range of resources which were being used by the middle of the twentieth century far exceeded the few, simple and obvious materials which had provided the basis for nineteenth-century industrialization, scientists and engineers agreed that they had only scratched the surface of potentialities. Only about one-third of the known elements were extensively used in industry, another third were in very slight use and the remainder were still entirely outside the scope of industrial application.

At mid-century divergent answers were being given to the question of whether man by his command over nature was so exhausting the resources of the earth as to lay an unsound basis for future generations, or whether the process of technological development itself was so enlarging the range of possibilities that the balance was on the side of ever more abundant resources rather than of their depletion. Some chemists claimed more limitless possibilities than others saw for the materials creatable through the chemical industry. Some mineralogists were disturbed by the exhaustion of old minerals while others envisaged the utilization of new. Some thought that economy in the use of materials was tending to balance new demands, pointing to the single pound of material per horsepower in high-speed aircraft engines as compared with the one thousand pounds of material per horsepower in the early internal-combustion motor, or the negligible amount of materials and power required for heating and cooling by means of such new devices as the reversible heat pump.

Three points only were clear: that at mid-century the limits of technological possibilities in developing resources on the basis of already known scientific principles were nowhere in sight; that the future pattern of resource use would undoubtedly involve as fundamental a shift as that of the preceding fifty years, which had seen the replacement of wood and coal by petroleum for fuel, of

wood and brick by concrete and steel for construction, of iron by alloy steel, aluminium and magnesium in much machinery, and of wool, cotton and leather by synthetic fibres and plastic materials; and that the essential resource upon which mankind would depend for its industrial future was not any specific physical material but technology itself.

III. ENERGY

Power lay at the heart of industrial society, for it was the use of energy to operate machines and implements that increased productivity and altered the character of the production process itself. The use of energy was the chief measure of a society's degree of industrialization and mechanization. Following the oft-quoted dictum of Lenin, 'Communism is Soviet rule plus electrification of the whole country', the USSR expanded its production of electricity more than a hundredfold during its first forty years, it put into operation in 1959 the largest hydroelectric project in the world and it was feeding its growing volume of power into an immense grid designed to extend from Leningrad to eastern Siberia. Japan's thorough electrification after the first world war sustained her nation-wide industrial development. For the people of central Africa the great Kariba dam on the Zambesi was the surest evidence of Africa's emergence into the modern world. The Chinese People's Republic, in its determination to provide a base for massive industrialization, projected a dam for the Yangtze river designed to produce more than ten times the power generated by the Grand Coulee dam in the USA, which had been the largest hydroelectric installation in the world in 1955.

In the first half of the twentieth century the world's supply of energy from mineral fuel and water power increased threefold. The energy actually put to work increased very much more because the efficiency with which supplies could be used doubled for the world as a whole during this period.

Almost all of the increase however was in the highly industrialized countries. On a *per capita* basis in 1950 the only country outside North America, Europe and Oceania that was using one-tenth as much energy as the highest energy-user, the United States, was Israel. With the exception of Japan no Asian country used as much as 5 per cent. India, the Asian country with the second largest industrial output, used less than 2 per cent as much energy *per capita* as did the United States, while Indonesia, Pakistan, Burma and Thailand used less than 1 per cent. The Latin American and Caribbean countries ranged from Argentina with slightly less than 10 per cent the *per capita* energy consumption of the United States to Haiti with ·003 per cent. The disparity between the energy consumption of the industrial and non-industrial areas had been growing as the consumption of the former increased. It would clearly require heroic efforts by the industrializing countries to close the energy gap.

The sources of power upon which industrial development depended

changed markedly during these years, and at mid-century further major changes appeared to be in sight.

At the opening of the century the world was drawing about 40 per cent of its non-human energy from work animals, wood fuel and wind and 60 per cent from mineral fuels, almost wholly coal. At mid-century more than 80 per cent

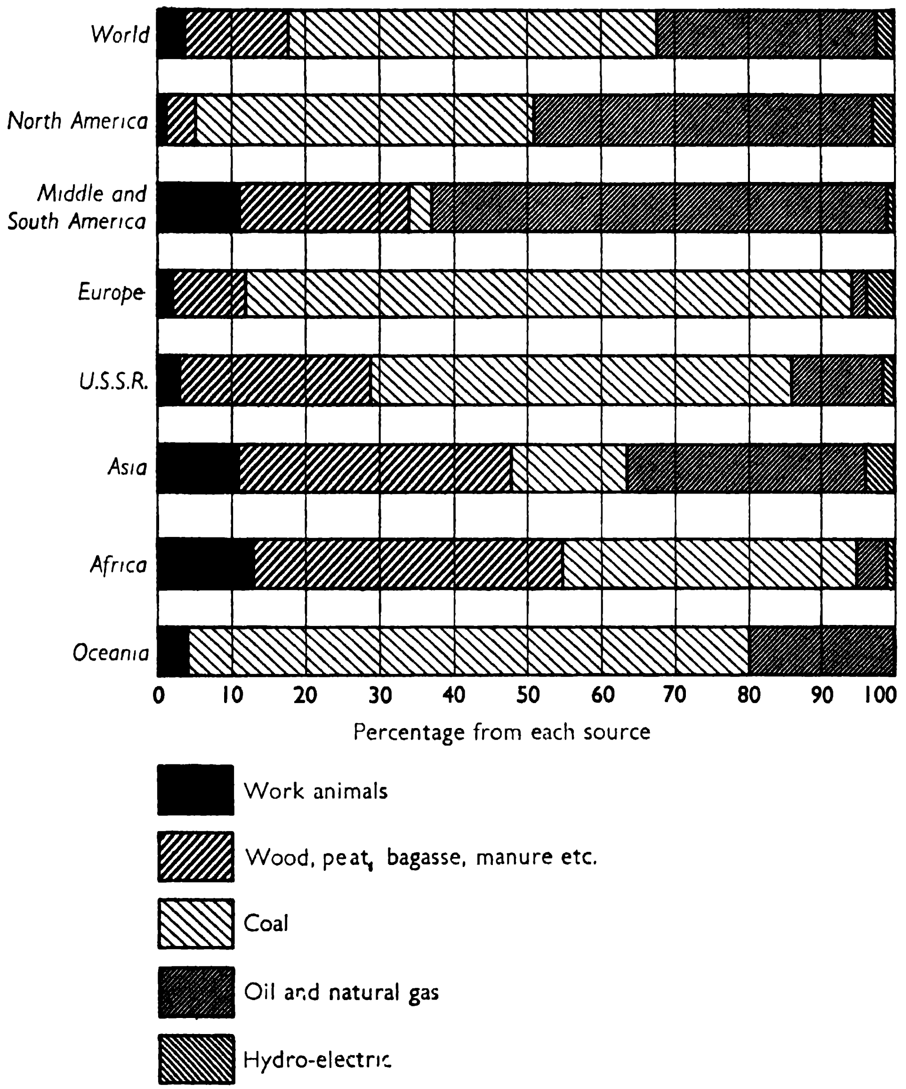


CHART X. Supply of Energy by Continent, 1948. (Percentage from each source.)

Source: Woytinsky, *World Population and Resources*, p. 931.

came from mineral fuels and water power, and of this coal supplied only three-fifths while more than a quarter came from petroleum and the rest from natural gas and hydroelectric power.

In the industrial countries the shift was much more complete. The United States in 1900 was already drawing nearly 98 per cent of its work energy from mineral fuels, almost wholly coal. In 1950 coal supplied a quarter of the work

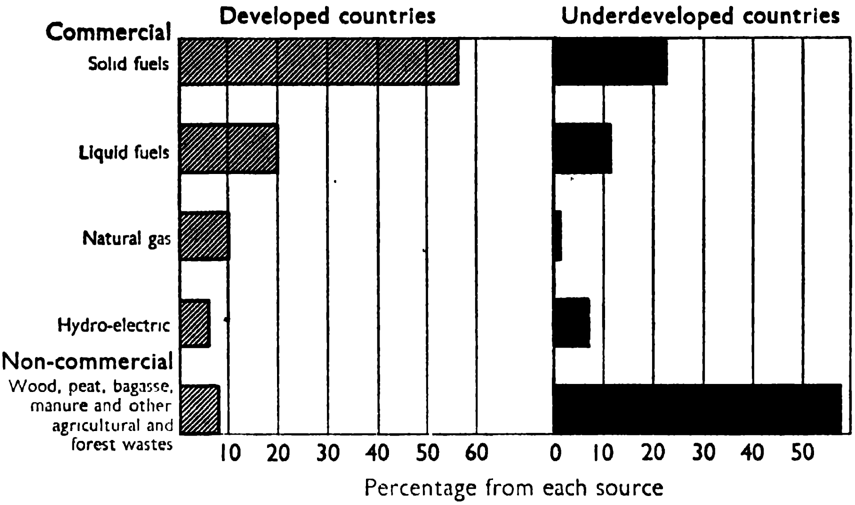


CHART XI. Consumption of Energy in Developed and Underdeveloped Countries, 1959. (Percentage from each source.)

Source: UN, *World Energy Supplies*, Statistical Papers, Series J, No. 1.

energy used, as against 58 per cent from petroleum, 15 per cent from natural gas and less than 2 per cent from hydroelectric power. Western Europe (OEEC countries, 1953) at that time was drawing over 80 per cent of its energy from coal, about 15 per cent from petroleum, 3 per cent from hydroelectric sources and a negligible proportion from natural gas.

Whatever its source, energy came to be delivered for use in two principal forms, electricity for more or less stationary operations and the internal-combustion engine—petrol or diesel—for mobile power. Steam continued important but tended more and more to be converted into electricity rather than to be used directly. Diesel engines were also extensively used for electric power generation, specially in small installations. In cold climates considerable energy of course continued to be used directly in the form of heat.

In the early stages of industrial development industry had been closely tied to its power base. Power transmitted directly by means of shafts and belts from water-driven wheels or stationary steam engines had limited factory location to the immediate vicinity of these sources. Machines within a factory

had to be arranged in such a way that they could be connected mechanically with the power source and much of the factory space was filled with moving belts.

Although the electric motor was known before the end of the nineteenth century it only began to be used in industry in the first quarter of the twentieth century and to determine the character of industrial processes in the second quarter. Electric motors provided 5 per cent of manufacturing motive power in the United States in 1900 and 80 per cent in 1950. In Europe they began to be used substantially in the 1920s and remained less general than in the United States at mid-century.

Electrification of industrial processes made it possible for power to be applied in small or large volume and at places distant from the power source. Electricity was carried by high-tension lines as much as 300 miles from generating points; at mid-century the distance was being greatly extended. Although factories using very large amounts of electricity in their processes, such as aluminium refining plants, found it advantageous to be sited close to power supplies, most plants could be situated with little regard to the origin of the power on which they depended. In some areas, moreover, the power supply of one region was linked to that of the next through a common grid permitting the substitution of current from one source for that from another as demand fluctuated; especially where grids spanned time zones, they could distribute peak loads. In Britain a well-developed grid throughout the country gave great flexibility in power supply. Grids on the European continent were to some extent linked internationally. The grid under construction during the 1950s in the USSR, designed to link all parts of the Soviet Union, carried power at higher voltages than were used elsewhere and thus permitted long-distance transmission without serious loss. (Pl. 7.)

Electricity, moreover, revolutionized the factory itself. It was no longer necessary to arrange machinery to permit the transmission of power by shafts and belts, with consequent crowding and danger to workers from moving parts. Power could be delivered to any spot within the plant, equipment could be arranged for convenience in handling the material that was being processed, individual machines, and even parts of machines, could be operated independently of one another, and many small operations which had had to be done by hand because mechanically delivered power was too clumsy could be performed with electrically driven hand tools plugged into a current outlet at the work bench. A major result of eliminating the shafts and belts used in the transmission of mechanical power was to allow clear space for equipment conveying materials to and through the work site.

Some industrial processes, especially construction, involved operations which could not be carried on by fixed machines and for these, as well as for all types of transport, the internal-combustion engine provided power in the necessary form.

The essential principles of the reciprocating engine operating by fuel

ignited under compression were known, and their application was worked out during the late nineteenth century. The four-stroke engine in which highly volatile gas and air are mixed in a carburettor, compressed and ignited by a spark had been in commercial production since 1877, and in 1897 Rudolf Diesel had made practical the two-stroke engine in which a charge of lower-grade fuel is self-ignited at the high temperature produced by the high compression of the air into which it is injected.

Both these types of engines were gradually improved and adapted to the multitude of purposes to which they were applied, as experience, new materials and new methods of refining fuels permitted. Diesel engines were developed mainly for heavy duty, such as railway locomotives, very large lorries and stationary equipment, while petrol engines of equal power but perhaps only 5 per cent of the weight were designed for aircraft, and petrol engines of every size drove motor cars and all manner of mobile equipment in factories and on farms.

An alternative type of internal-combustion engine, the gas turbine, had also been designed and placed in successful operation at the opening of the century, but its practical use depended upon the development of metals which could resist extreme heat. In reciprocating engines materials had to resist the peak heat only during the moment of explosion, but in the turbine the process was continuous and speeds extremely high. When the jet propulsion principle began to be applied to aircraft during the second world war, i.e. when the exhaust gas was used as the driving force instead of being treated as waste, the high-speed turbo engine proved the most suitable type. Once the metallurgical problems were solved, turbo-jet engines became standard for military aircraft and for a rapidly increasing proportion of civilian planes. In the development of missiles and space vehicles, the ram-jet principle and new fuel gave even greater power. While these new instruments were developed primarily for airborne and space travel, they extended the range of possibilities for the application of energy to productive tasks.*

The rapidly rising level of fuel consumption in the industrial countries, and the enormous prospective needs in the rest of the world, brought to the fore the problem of whether the world's energy resources were sufficient to continue to sustain industrial activity and growth.

With the rate of petroleum consumption rising rapidly, fears were repeatedly expressed that petroleum might be in short supply by the end of the century. In 1942 the world consumption of petroleum products exceeded for the first time the new supplies discovered during the year. At the rate of increase in consumption at mid-century, the proved supplies would have lasted little more than fifty years. But unproved supplies in the Middle East were thought to be many times the proved amounts, great fields in the Sahara were being opened up, and exploration for new resources was being carried on in many parts of the world. Improved methods of extraction,

* See Chapter X, Transport.

including the flooding of fields to force out oil left in the ground after pumping—sometimes amounting to as much as the total which had been pumped out of the field—increased the yield from known sources. Other technical developments opened the possibility of extracting oil from shale.

Some scientists, however, predicted that a substantial proportion of petrol supplies would be derived from coal rather than petroleum before the end of the century. World reserves of coal remained large, with little immediate prospect of exhaustion, though some of the older sources on both sides of the north Atlantic were becoming less and less productive.

On the basis of data and analyses presented to the 1955 Geneva conference on the peaceful uses of atomic energy, it appeared that world reserves of conventional fuels were sufficient to meet increasing needs for a hundred years. But the location of reserves did not match areas of consumption, and it appeared that few regions of the world would be able to meet their energy requirements by the end of the century from these sources without a considerable increase in price.

Although only a small proportion of the energy consumed in the world at mid-century came from hydroelectric power, this source had gained in importance and immense resources remained untapped. Estimates as to the amount of water power available were necessarily uncertain in view of constantly changing technology which made it possible to harness more remote and difficult flows. It appeared however that an amount equivalent to half the total energy which the world was consuming at mid-century might be derivable in the future from the great resources in the Himalayas, Africa, the Andes, the Amazon and the Orinoco, the Columbia River basin of the United States and Canada, and the great rivers of Siberia and China. In addition the power potential in the ebb and flow of the tides had not been exploited to any substantial extent. Nearly half of the world's estimated untapped water power lay in Africa, approximately one-eighth each in Asia, South and Central America and the USSR, and the remainder in North America, Europe and Oceania.

Only about 13 per cent of the world's usable water power had been harnessed, including more than 60 per cent of that available in Europe, half of the North American supply, 3–6 per cent of the usable potential in South and Central America, Oceania and the USSR, a negligible amount in Africa, and some 13 per cent in Asia, almost wholly in Japan and Korea. Among the countries of the world only Japan, France, Sweden, Germany, Switzerland, Austria and Italy had tapped their water power resources anywhere nearly to the full, measuring these resources in terms of the minimum flow during the dry seasons of the year without considering the additional supplies that might be stored from rainy periods.

Great hydroelectric projects were at the heart of the USSR's industrial development programme. Dams and generating stations on the Volga and Dnieper rivers were included in the early five-year plans and these were

promptly reconstructed after the destruction suffered during the second world war. In the period after the war the Soviet Union was doubling its hydroelectric capacity every five years, with gigantic projects on the Siberian rivers, at least one of which was designed to generate more than twice the volume of electricity put out by any existing plant elsewhere in the world.

Other countries seeking industrialization gave hydroelectric projects a central place in their national plans. India looked to her great rivers as a major source of much-needed power; her Damodar Valley project was designed to form the basis of a great steel complex. The Chinese People's Republic, short of equipment but determined to lay a basis for economic development, set some 20,000,000 of its people to work on river projects during its first decade of existence. The high Aswan dam on the Nile, the Volta River project in West Africa and the Kariba dam on the Zambesi in the Central African Federation marked the beginnings of major developments on the African continent. (Pl. 10a, 10b.)

It was characteristic of hydroelectric projects that they could be undertaken as multi-purpose enterprises, for flood control, inland transport and irrigation as well as power generation. The concept of river valley development, first made famous by the Tennessee Valley Authority (TVA) in the United States in the 1930s, became the basis for multi-purpose projects in many countries, with one or another aspect dominant—flood control and inland navigation in China, irrigation in India and Egypt, power generation in the USSR—but with most or all features included in the total plan.

At the middle of the century two major new sources of power were beginning to be exploited, atomic energy and solar energy. Atomic power, first developed for purposes of destruction, was being harnessed practically for industrial use; the USSR, Britain, and the United States all placed atomic generating stations in operation for the commercial production of electricity in 1956 and 1957. The 1955 Geneva conference on the peaceful uses of atomic energy revealed a great range of experimental undertakings which indicated the likelihood of early and eventually widespread use of atomic power for industrial purposes, especially in those areas where other sources of energy were scarce or costly. Nuclear fuels, it found, were abundant—many times more abundant than the world's coal reserves—and could be obtained at a reasonable price. Several types of machines were successfully extracting energy from nuclear fuels at costs already not much higher than that of energy obtained from coal or petroleum. Since costs could be expected to drop below those of energy from coal or oil, atomic power generation appeared to offer a practical resource to countries where there was sufficient technical personnel to operate the complex mechanisms. European countries joined in 1953 to form a permanent European Organization for Nuclear Research (CERN) which set up an international laboratory in Switzerland. In 1957 they established an organization, Euratom, to develop atomic energy for practical use. The USSR set up a Joint Institute for Nuclear Research in Dubna to

co-ordinate the activities of scientists from socialist countries. In 1957 the International Atomic Energy Organization, with headquarters at Vienna, came into existence as a specialized agency of the United Nations.

Investigations were also under way to find means of utilizing thermonuclear fusion as well as atomic fission for power generation following the development of this process in connection with the hydrogen bomb. Since the materials for the latter process were far more plentiful and cheap than the uranium on which atomic fission depended, these experiments opened the possibility of an even more universal and ultimately economical source of power. The problems of radioactive contamination or danger had not yet been solved, nor was there yet a supply of atomic scientists and technicians who could design and operate installations in some of the regions where such power might be of particular importance. There was little doubt however that atomic energy would become a major source of industrial power in the future.

Extensive work was also in process at mid-century to draw power from the enormous volume of solar energy reaching the earth, especially in the tropical areas and in arid zones of constant sunshine. Solar energy was already being used successfully on a partial or experimental basis, to distil fresh water from the sea, for irrigation pumps and other small engines, for stoves and high-temperature furnaces and for charging electric batteries. The principal problem in the utilization of the sun's rays, the very small amounts in which solar energy reaches any given point, was being overcome by constant improvements in design. A practical solar battery for boosting small amounts of electric current had been installed on rural telephone lines in the United States, and had attained the relatively high efficiency level of 11 per cent; a large solar plant to generate electricity and pump water was under construction near Abidjan, in West Africa. Marked progress was being made in Israel. At the first world symposium on solar energy held at Tucson, Arizona, USA, in 1955 some 900 scientists and industrialists from thirty-four countries and all continents met to discuss scientific and practical aspects and to view examples of more than fifty different solar devices.

While the possibilities of atomic energy were of greater importance to countries with limited sunlight and high rainfall such as Great Britain and northern Europe, and although the fact that the sun could generate power only during daylight hours presented storage problems in all regions, solar energy seemed to offer to tropical and arid areas a hopeful possibility for a plentiful and ultimately cheap source of power.

IV. INDUSTRIAL PLANT AND EQUIPMENT

1. *Productive equipment*

It is obviously impossible to discuss in any detail the variety of equipment to produce every imaginable type of product, but it is possible to note in broad

terms some of the characteristics of design and operation which marked the major trends of twentieth-century development.

The features which most distinguished the productive equipment of twentieth-century industry from that of the nineteenth century were the widespread use of electrical and chemical rather than primarily mechanical processes and the increasing extent to which operations were automatically controlled. Nineteenth-century machinery was almost wholly mechanical in design and operation, and much of the productive equipment of twentieth-century industry also represented a refinement and elaboration of mechanical principles. But electrical and chemical processes gained in importance, over and above the use of electrical energy to drive equipment, and became vital to many key industries.

Electric processes revolutionized many aspects of metal producing and metal working industries, both in the extraction of metals from ores and in the production of alloys. Electric furnaces provided the higher and better-controlled temperatures needed for making special steels and other high-grade metal alloys. Electric welding was used in much metal working in place of riveting, reducing costs and improving quality; it permitted the virtual flowing together of joined surfaces without weakening or distortion and, together with various forms of electric soldering and brazing, it became the principal method for joining metal parts. Induction heating of materials was used to give different parts of the same object quite different properties of strength or hardness. Electro-erosion methods of cutting and processing metals supplemented mechanical cutting.

Electrolytic processes for the extraction of metals became the basis for aluminium and other light metal industries. Electromagnetic attachments on the pick-ups of cranes were used for moving masses of iron and steel. Electric charges in gases produced such instruments as neon lights. Electric cooling systems provided air conditioning, refrigeration and freezing treatment. Electric power greatly facilitated the design of automatic devices and powered X-rays to detect imperfections.

The most striking use of electricity to perform vast new functions was in the field of electronics. From 1906 onwards the vacuum tube, with its capacity to capture and amplify infinitesimally small amounts of current, and after 1948 the transistor also, not only revolutionized communications,* but became the basis for a multitude of devices to control industrial operations.

Another large proportion of twentieth-century production depended upon chemical processes, sometimes in conjunction with the use of electric current as in electrolytic methods for refining metals, sometimes in combination with mechanical processes as in powder metallurgy where metal sheets were formed under great pressure from metal powders, and sometimes as an entire chemical process in plants producing synthetic fibres, plastics, photographic film and other man-made materials from chemical elements. In other

* See Chapter XI, Communications.

types of production, such as oil refining, chemical processes were used to affect materials rather than to create them. Not only in essentially chemical industries themselves, such as drugs, fertilizers and synthetics, but in many other lines chemical treatment figured at some step in the production process.

Although major innovations were most generally based on electrical and chemical processes, mechanical devices retained their importance and were greatly refined. In metal producing and using industries, machines were developed to permit continuous operation of both rolling and casting, to cast by a variety of improved methods which minimized the necessity for subsequent machining, to handle metals in a non-molten state as in cold rolling of steel and other plastic deformation of materials. Mechanical handling of other types of material was elaborated with great precision and complexity.

Many of the most important mechanical innovations depended upon the arrangement of equipment rather than on any specific operation. Workers or machines, each repeating simple actions, were so arranged that the product could pass from one to the next without loss of motion or the need to carry partially worked products elsewhere or to store them until they could be put through the next step.

The assembly line, introduced by Henry Ford in the automobile industry in 1909 and extended to many types of production, established the principle of the moving belt which brings the product to one worker after another, each of whom performs a limited function during the short time that the object is before him. Once the simple, repetitive components of a production process have been so organized as to be part of a continuous flow, with each bit of material or part arriving at the right place at the right moment, machines can frequently replace workers. In many industries long, complex systems of production came to be carried through by machines from start to finish. Engineers were increasingly called on to design whole systems, not single machines, and each new device had to be engineered in terms of its place in a series of operations, not merely for the specific function which it must perform. (Pl. 8.)

Elaborate assemblies timed for a continuous flow and dependent on having every component at the right place at the right time became more and more complex. Since lack of any one part would hold up the entire costly operation, large producers tended to manufacture their own parts rather than to depend upon suppliers who might fail to meet their deliveries because of a breakdown, strike, fire, transport difficulty or excess number of orders. But in the manufacture of complicated products such proliferation of processes often became cumbersome and introduced uneconomic variety into the operations of a single enterprise. The opposite tendency was for a plant to concentrate on a single component and to perfect techniques for its economic production. This interplay between the tendency to integrate more and more processes in order to achieve a continuous flow and the tendency to specialize in order to achieve maximum economy went on constantly in the competitive economies, and the

same problem presented itself in the planned economies in the choice between alternative forms of organization and design.

All kinds of processes became increasingly automatic through the application of the cybernetic principle of self-regulation or feed-back, i.e. the use of devices which enable the machine to respond automatically to conditions created by its own operation and thus to adjust itself in order to maintain the desired condition. The principle itself was not new; it had entered the early stages of industry with the first governors on steam engines that controlled the delivery of steam to regulate the speed. But early types of automatic controls were based on simple mechanical principles. The availability of electricity greatly enlarged the scope of such controls. Electric switches which would respond instantly to the receipt of an electric impulse permitted the installation of many new types of control devices such as thermostats which registered temperature and transmitted an electric signal to cut off or turn on a fuel pump or blower in order to maintain constant heat. (Pl. 9.)

The development of electronic devices so stepped up the use of self-regulatory controls as to make these a central feature, not merely an incidental part, of production technology. These extremely sensitive instruments were designed to control immensely complex operations with a precision which far exceeded that which could be supplied by the human hand or by mechanical or cruder electrical means. Their introduction at an ever-accelerating pace was so dramatic that in the decade after the second world war they seemed to be bringing a new stage in technological development which earned the name automation.

In some industries, such as some oil refining and chemical works, whole processes were beginning to be controlled by electronic memory devices, or computers, which recorded information and instructions and transmitted them to a chain of machines in such a way as to keep the machines supplied, adjust all steps from raw material to finished product, automatically remove the finished product and wastes, inspect the product for imperfections and measure its quality, keep the machinery oiled and in running order, stop the process if anything went wrong and keep a record of what had been done. The cost of installing elaborate automatic processes made them particularly suitable for large mass-production operations that could be expected to produce sufficient volume over a period of time to repay the initial cost.

With the coming of atomic energy a further resource for efficient and economical automatic control of even greater precision and penetration was furnished by the radioactive isotope. From the initial experimental introduction of radioactive particles as tracers, their use grew by leaps and bounds. They were soon being relied upon for such purposes as detecting faults in metals or machines, registering the amount of wear on important parts, controlling the gauge of rolled steel, paper or plastic sheeting or checking the quality of oil travelling through a pipeline.

The production of equipment of all types depended upon the machine-tool

industries, on the machines that made the machines and the technical personnel with the knowledge and experience to design and construct new equipment for new purposes. These industries were both the foundation and the mainspring of industrial development. Although the basic tools for machine production—lathe, drill press, metal plane, and machines for milling, boring, shaping and grinding—had been developed in the nineteenth century, their improvement through the use of high-speed steels, the introduction of new electrical and chemical techniques for working metals and the application of automatic devices transformed machine-making technology. In the machine-tool industries all the most refined techniques that were developed in any line were brought to focus to permit a degree of precision undreamed of at the beginning of the century.

The development of machinery was a cumulative process which depended on continuous improvement in design based on experience in use, the introduction of new materials and precision instruments as they were developed, the availability of parts or elements from other industries, and a corps of highly skilled and imaginative designers and mechanics with sufficient resources to carry out their ideas. The more complex and single-purpose the machine, the more costly the retooling for a change in design of the product to be made. In order to avoid both inflexibility and the need to discard old equipment, there was a tendency to design basic multi-purpose mechanisms to which different special-purpose parts could be attached. With the progress of standardization many machines became assemblies of standard parts which could be replaced as needed for repair or to vary the machine's operation.

In some fields, as for example military equipment during periods of war or intense international rivalry, changes in design came so rapidly that retooling was needed almost before the machinery to produce the original model was in operation.[9, 10] In the competitive economies changes in models in order to stimulate demand for the product, as in the automobile industry, led to periodic retooling as part of the pattern of industry; but on the other hand a strong company seeking to protect its investment sometimes bought up and suppressed a new design in order to avoid the necessity of discarding existing productive equipment.

Production of machinery was heavily concentrated in the most highly industrialized countries. Prior to the second world war 85 per cent of the world's machinery was being produced in the United States, Great Britain and Germany, with the remainder distributed among several west European countries, the USSR and Japan. In volume, the United States passed Britain and Germany and for a period after the war was producing more machinery than the rest of the world combined, though this relationship was changing with the restoration of the European economies and the expansion of output in the Soviet Union. British mining machinery, German electrical equipment, Swedish ball bearings and Swiss high-precision devices occupied special places on the world market. Japan offered a number of economical types of

machines, generally less sturdy in construction but lower in cost than those produced in Europe and America. The Soviet Union developed extensive machine-making capacity to supply its expanding industries, often designing and constructing very large units for its typically large-scale establishments and making wide use of automatic controls. In the decade after the second world war it supplied equipment for the industrial expansion of the people's republics, and was beginning to offer industrial equipment to other parts of the world.

The concentration of machine production in highly developed industrial countries reflected the fact that more than any other branch of industry machine tools depended upon the highest skills and the most varied resources of the entire scientific–industrial complex.

2. *Size of plant*

Wider markets, greater mechanization and the techniques of mass production brought a trend toward large-scale industrial establishments. The very large plants, and even more the large firm with several separate factories, came to be the dominant unit in many fields. In the United States and Great Britain an increasing proportion of workers were employed in large plants in spite of the fact that these were usually more highly mechanized and required fewer workers for a given volume of output than did smaller units. In the planned development of the USSR, with its large domestic market and central direction, large-scale units were established wherever possible, especially in basic industries.

Industries differed from one another however in the characteristic size of their establishments, and these differences persisted. The garment industries for example retained small shops since their technology did not require large-scale operations and small shops gave flexibility. Heavy industries such as steel or automobile manufacture tended toward large plants for economy in mass production. It was not clear how far the general trend toward the large plant reflected technological developments and how far it resulted from the shift toward the kinds of industries in which large-scale operation was particularly advantageous.

Even in many industries dominated by the large plant, moreover, the small establishment did not disappear. While large plants produced standard, bulk products, smaller units turned out specialized items, parts for large-scale manufacturers, and things for which demand was less steady and the risks often greater. In some countries small plants were encouraged by public policy on the ground that they preserved competition, or that they were less vulnerable to physical attack than large units, or that they were essential to balanced industrial development. India at the start of its industrial expansion made special efforts to encourage small establishments, particularly in smaller communities, in the effort to keep workers from concentrating in the cities. In Japan, where there was a sharp dichotomy between large-scale enterprise

operated by a small group of large concerns and the small and medium-sized family firms, small plants tended to serve as the shock-absorbers of industry, receiving orders from the large, continuously operating plants when times were good and being left without work in slack periods. In countries too small to provide a mass market for some types of product, only those industries which produced for foreign trade could operate large-scale units.

Although there was much discussion as to the optimum size of industrial plant there was little agreement even for particular industries and particular countries. One trend however appeared clear. Large enterprises had the capacity to grow larger and larger as technical processes, management methods and efficient communication made it possible to operate very large factories effectively and many separate plants under common direction.

3. *Plant location*

Industrial plants tended to be localized in certain areas, partly in relation to raw materials, partly in relation to the market for their products and chiefly in relation to the presence of other plants and other industries. The shift in their source of energy from direct water power to steam and then to electricity gave them flexibility and much freedom to choose a site which appeared favourable.

In different countries similar industries tended to follow similar patterns of location. Those which worked a bulky raw material or a perishable commodity whose transport was costly or difficult, such as cement plants or fish or vegetable canneries, clung near their source of supply. Those such as bakeries or machine shops or printing establishments, which supplied the market with a perishable or bulky product or carried on an operation which included services, were located near their customers. Some which required extremely large amounts of power, such as aluminium processing plants, sought a cheap power source. A few, making dangerous products such as explosives, required isolation and space. But a large proportion of all industrial establishments, limited by none of these factors, simply gravitated to an industrial zone.

The nature of most industries made it advantageous for them to be close to others. They were mutually dependent for the products which entered into manufacture; they wanted to be near a supply of workers with varied skills and to be able to attract skilled and imaginative management; they depended on many supporting services such as printing, financing, advertising, repair; they needed access to transport, power and information. Once a locality had acquired these features it acted as a powerful magnet to draw more plants to it, with a pull so strong that even the danger of bombing in wartime could not overcome it.

Yet some contrary factors tending to disperse industry grew in importance during this period. The possibilities for using electricity as a basis for dispersion were well demonstrated in Japan, where a combination of electrification and extension of railways after the first world war spread industry through

the country into many towns and cities of differing sizes. The development of rapid transit systems permitted workers to commute long distances to work and the flexibility of motor transport for both products and workers also made dispersion possible when other factors were favourable. Air transport enabled managers and executives to supervise plants at a distance one from another. High land costs in central urban areas and ordinances excluding plants which emitted unpleasant odours or noxious substances contributed to the dispersing of industry outside major centres. Some industries or individual plants moved to new locations which offered cheap labour.

Nevertheless the tendency toward local industrial concentration remained strong even where positive public efforts were made to counteract the tendency in order to reduce problems of urban congestion. Great Britain after the second world war established new medium-sized towns with facilities to attract industries. Communities at a distance from industrial districts in the United States offered low taxes, reduced rents and cheap power to try to induce industry to locate there. For a time new industries in the USSR were excluded from the larger cities. India's community development programme included the development of small industrial centres linked to surrounding villages. But the disadvantages of isolation in small industrial communities proved a powerful obstacle to dispersion, and industry tended wherever possible to spread its plants within industrial regions rather than to scatter them more widely through non-industrial areas.

4. *The factory as a place of work*

The factory of the nineteenth and early twentieth century was more often than not ugly, dark, poorly heated or cooled, noisy, grimy and often a dangerous place where workers were exposed to dust, heat, damp or physical injury. Some of these conditions were inherent in the processes themselves—the heat of molten metal, the clang of a forge hammer or the slap of an automatic loom, the constant motion of whirring shafts and moving belts; some merely reflected indifference to the conditions under which human beings were expected to work.

Many of the technical changes in industrial processes brought changes within the factory which made possible the light and airy modern plants which came to set the standards. The substitution of electric motors for moving belts laid the basis for clean well-arranged factories. Air-conditioning and electric lighting provided temperature and humidity control and sufficient light in all places. The atmosphere of the plant was adjusted to provide optimum conditions for manufacturing the product and this usually meant a constant level of heat and humidity and the elimination of dust. Where automatic controls were used, gauges and controls could be placed in a separate room where conditions could be adapted to the comfort and efficiency of the workers. The number of factory tasks that had to be performed under

hazardous or unpleasant conditions was greatly reduced by the new technological processes.

Modern factories, moreover, were designed to stimulate the efficiency and productivity of workers by the impact of their surroundings. Colours which lent a cheerful atmosphere replaced the traditional drab walls. Machines were painted in such a way as to facilitate the identification of different parts. The result was not only to raise worker morale but to encourage cleanliness and increase safety and efficiency. Some factories found that productivity was increased when music was played continuously.

Factory design attracted the talents of some of the most imaginative architects in many countries, who could take full advantage of new materials and functional design without being restrained by traditions which limited their freedom in the construction of homes and public buildings. They not only created efficient interior work spaces and well-proportioned building units but set the industrial plants amid lawns and made industrial districts into features of a city plan instead of the eyesores which the older industrial areas had been.

Model factories were by no means representative of the conditions under which the majority of industrial workers laboured, especially in older industrial countries, older centres within such areas, and older industries, for many obsolete buildings remained in use or were occupied by small or struggling concerns when their original owners moved to more up-to-date quarters. But new factories as they were built took on these characteristics. It was a far cry from the conditions of English workers described by Friedrich Engels in 1843 in *Die Lage der arbeitenden Klasse in England*, or from the crowded loft from which New York garment workers leapt to their death in the Triangle fire of 1910, to the industrial parks which commanded the approaches to many cities in the 1940s and 1950s. In the words of the International Labour Office: 'It is hard to imagine a sharper contrast than that between the typical drab, dark, smoke-ridden nineteenth-century factory and the model factory of the twentieth century, light and airy, with attractive interior colour schemes, in well-laid-out grounds with lawns, trees and flower beds. The model factory is not yet typical, but it sets standards that more and more factories are approaching.'*

V. LABOUR SUPPLY AND UTILIZATION

Changing technology greatly altered the kinds of labour required by industry and the manner in which workers were used. In the countries of advanced industrial development mechanized mines and factories and the vast network of mass production and distribution called for workers with many new capacities. These needs were met by the development of an educated, trained and responsible labour force and its use under conditions which enhanced its

* International Labour Office, *Higher Productivity in Manufacturing Industries* (Geneva 1954). Studies and Reports, New Series, no. 38, pp. 159–160.

productivity. At the same time the goods which industry produced entered into the worker's standard of living and provided much of the motivation for his effort. Industrial labour thus both contributed to production and became its beneficiary.

In the non-industrial areas the situation was different. There the expansion of industrial-type employment, whether in mines, in developing industries or in plantations which functioned as factories in the field, generally failed to keep pace with the drift of workers away from subsistence agriculture, and industries were therefore under few pressures to make efficient use of labour which was plentiful and cheap. Foreign companies often depended upon workers from abroad for the higher levels of skill. Only gradually did industrial labour in the developing countries begin to take on some of the characteristics of the labour force in the older industrial areas, though the trends were in the same direction; in none of these countries did workers begin to provide a mass market for industry's products.

1. *Unskilled labour*

In the early stages industry had required large numbers of unskilled workers to perform repetitive tasks and tend simple machines. The need for such workers continued to some extent, for as soon as machines were devised to replace workers on simple operations, the more complex processes that formerly required skill were broken down into a series of steps which unskilled or semi-skilled workers could perform. The tendency, however, was toward the use of semi-skilled operators rather than the types of unskilled workers who supplied mainly physical or mechanically repetitive labour.

Industry recruited these workers wherever it could find a cheap supply of hands, tapping groups whose other means of livelihood were inadequate. Most of the unskilled workers were drawn from agriculture, both within the industrial countries and from abroad. British industry had already absorbed almost the entire supply of rural workers by the opening of the twentieth century; less than 10 per cent of the British labour force remained in agriculture at that time and only 5 per cent by 1950. Other industrial countries sucked great numbers of their rural workers into industry, until by mid-century less than a fifth of the labour force in such countries as the United States, Canada, Australia, the Low Countries, Germany and Sweden remained on the land. In addition, American and Canadian industry drew heavily on peasant immigrants from eastern and southern Europe as did, to a lesser extent, some of the industries of western Europe and of other overseas areas. Japan's industries drew on a pool of available rural labour throughout their development. South Africa brought native Africans as labourers into its mines and factories.

Workers could be drawn from agriculture into industry during this period without cutting down on the needed supply of food because of three main factors: the highly productive virgin land which had been opened up in North

and South America, Oceania and southern Russia was producing ample supplies of wheat and meat to feed the industrial populations of Europe and America; in areas of subsistence agriculture under-employed or under-productive workers, scraping a living from poor or subdivided land, left agriculture as fast as other employment became available; and in regions of advanced agriculture the great increase in productivity resulting from technological improvements released much labour from the farms.

Women were also a major source of factory labour, especially in light industries such as textiles and garment-making. Throughout the period under review women continued to constitute from a quarter to a third of the industrial labour force of most industrial countries and more than 50 per cent in Japan prior to the second world war.

The essential quality required of unskilled workers was the ability to respond to the discipline which the productive process and the machine imposed. They must perform reliably and accurately the task on which the work of the next in line depended, with the endurance to sustain a uniform rate and quality of output throughout the work period. New workers had to adjust to industrial discipline in order to become effective members of the industrial labour force. Especially for those who entered industry from agriculture, this involved a new manner of work and way of life, and the transition was usually accompanied by much instability in employment, absenteeism and the need for training. Workers accustomed to following the seasons and their own rhythm of work found themselves bound to the pace of the machine, required to perform a prescribed task at a prescribed time, dependent on the work of others and having others dependent on them.

Adjustment to the discipline of industrial production was thus an experience common to large numbers of twentieth-century men and women in most parts of the world. In an effort to expedite the process, employers who had little regard for their workers as human beings placed them under various forms of pressure, such as holding gang bosses responsible for seeing that their gangs performed their tasks, or imposing financial penalties on workers for failure to meet norms or for irregularity in attendance or performance. Those employers who were more aware of social factors tried to create some of the social conditions which would contribute to stability, as did groups of employers in several Latin American countries who made use of social workers with this objective. The USSR developed a number of systems for inducting new workers, publicizing workers' performance and placing responsibility for sustaining rates of output on fellow workers. By mid-century some progressive industries in some countries were making positive efforts to avoid placing workers in tasks for which they were not suited, and were attempting to plan work tasks, schedules and methods of supervision that were more consistent with human needs; some tried to enable workers to understand the significance of their contribution to the total work process and to derive satisfaction from group participation.

Because the principal qualities which factory operatives required were flexibility and stamina, industry tended to employ younger workers by preference. The bulk of factory employees were young adults. The young children who had made up a large part of the factory labour of the early nineteenth century were no longer used. Laws requiring school attendance and prohibiting child labour had already sharply limited the employment of children under 14 by the opening of the twentieth century, and by mid-century children had almost disappeared from the industrial labour force. Those between 15 and 20 were employed extensively, but the proportion of boys of this age who entered employment dropped substantially as opportunities for secondary education increased and more of the available jobs required education. The proportion of boys aged 15–19 at work in Great Britain dropped from 92 to 83 per cent between 1901 and 1951, and the proportion aged 14–19 in the United States fell from 64 to 40 per cent in the same period.

2. *Skilled workers*

Industry continued to need workers with a variety of skills acquired through substantial periods of training or apprenticeship, but traditional and specialized skills were constantly made obsolete by new techniques. To survive in the face of changing technology, skilled workers must be above all adaptable; they had to have a basic understanding of machine processes in order to handle various types of machines and the ability to be quickly trained and retrained for specific jobs. Often the technological change required not merely retraining but a quite different category of workers. The demand fell for craftsmen shaping the product by hand tools, but increased for toolmakers, for mechanics to set up and repair machines, and for draughtsmen to prepare blueprints. With complicated and delicate machinery to be safeguarded and employed as fully as possible, supervisors and foremen became particularly important.

Many who possessed old skills were reduced to unskilled or semi-skilled tasks, forced to learn entirely new trades or faced with unemployment. Older workers, proud of their crafts and accustomed to command good wages on the basis of them, repeatedly tried to resist the introduction of new procedures which could displace their type of work. The relatively slow rate of technological development in the construction industry, for example, reflected in part the success of building-trades workers in many places in defending their traditional methods. New techniques were more readily introduced where defenders of old skills were few or their organized efforts to resist change were weak.

Skilled operatives were produced within the factory by upgrading of semi-skilled workers, and they also entered industry from outside as young workers with vocational training or with good general education which enabled them to learn specific tasks quickly. The speed with which workers were upgraded varied with the state of the labour market. When labour was in great demand,

as in times of rapid industrial expansion and during war, every effort was made to bring workers up to higher levels of skill and to devise the most efficient means of doing so. In periods of unemployment, when many workers were employed at tasks below their level of skill, the upgrading and training process slowed down. In the expansion of American industry each successive group of immigrants or of migrants from rural areas moved up the job ladder as they acquired factory experience and command of English, while new groups of immigrants or migrants filled the least skilled and poorest paid jobs.

Individual companies and sometimes whole industries set up in-service training schemes. Such schemes tended to expand as industries came to need a larger proportion of trained workers. Some of the larger industrial corporations developed full-fledged programmes of technical and general education at all the levels of knowledge and skill which their operations required, and enrolled large proportions of their workers in courses designed to fit them for new jobs within the enterprise. During the first world war, and to a much greater extent in the second world war, governments took an active part in helping industry to provide such training through the development of training techniques, preparation of manuals and guides, and consultant services to plants engaged in war production. The USSR at all times made special provision to expedite the process of upgrading by offering courses of study for factory workers and placing great social pressure on workers to take advantage of them so that there would be a continuous supply of trained workers rising from the ranks.

For young people headed for industrial employment the educational systems of the industrial countries provided schools which offered vocational training to supplement or replace the apprenticeship methods by which skilled trades had traditionally been learned. Such training was both included within programmes of general education and offered in special technical schools or institutes.* Some of the older trades continued to be learned by apprenticeship methods, often controlled by craft unions, and apprenticeship schemes were developed in some countries for certain of the newer occupations. Thus skills related to mechanical operations and industrial production might be acquired either in school or on the job, and employment in such occupations was open to those who qualified by both of these means.

Industry often failed to employ certain types of workers, however, for a variety of reasons. Some potential workers were excluded from the opportunities to secure training. Vocational schools or classes offering some types of mechanical training were often open only to boys, even in countries where co-education was the general rule. Although women came to be freely admitted to institutions of higher education and could enter the professions in most countries, they often remained barred from skilled trades. A study of women's employment in Latin America in the 1950s revealed the almost complete exclusion of women from vocational training, except in the needle

* See Chapter XXVI, Education.

trades, and thus from most industrial employment above the unskilled level. Where prejudice against the employment of certain categories of workers existed, as it did against Negroes in many places and types of work, schools were reluctant to offer training to those who would not be able to secure jobs, and opportunities to enter apprenticeships were frequently closed.

When there was a shortage of workers, however, industry used and trained types of workers whom it had regarded as inadequate or undesirable. Under the impact of war women were employed in large numbers in tasks for which they had not been used before. Many of those recruited for such tasks during the first world war were dropped during the post-war economic slump, but after the second world war high levels of general employment led to the retention of women in many jobs which they had entered for the first time during the war. Industry also found that it could use older people and those suffering from various handicaps such as blindness, crippling or loss of limbs. During the second world war many older workers were called back into industrial jobs and proved to be adaptable and capable of retraining. Handicapped persons were successfully placed in tasks for which they had been presumed to be unfit, and after the war laws in some countries required employers to include a certain proportion of war-injured among their workers. The particular faculties needed to perform specific jobs were closely analysed and many such workers were put to work where their capacities could be used and their deficiencies disregarded.

3. *Technicians*

As industry applied more scientific knowledge and more elaborate technology it depended more and more on technicians, engineers and scientifically trained workers rather than on either unskilled workers or skilled machine operatives. The work force of factories or mines using automatic machines and controls or elaborate chemical processes was largely engaged in maintaining and repairing equipment, testing and inspecting materials as they passed through the production process, designing and constructing machines or developing new products. The more automatic controls replaced workers on the production line, the more need there was for people to design and construct the automatic devices and the machines which they controlled.

For these highly technical tasks industry required men and women with a wide range of scientific and technical training, from little more than the vocational skills acquired by the trained operative up to the highest level of scientific competence and imagination. The need for this type of worker expanded enormously as the rate of mechanization accelerated after the second world war.

To meet this large demand industrial countries stepped up their programme of higher technical education, expanding the technical faculties of their universities, offering other training at the university or post-university level, founding higher technical institutes and establishing scholarships and grants for technical, engineering and scientific training.

For countries in all stages of industrial development the expansion of higher technical education became a major concern in the years after the second world war. The USSR made its vast programme of technical education, symbolized by the towering structure of the Moscow University with more than 1,000 laboratories, the heart of its effort to achieve the highest level of industrial production in the world. Britain moved to fill the gap between its small, outstanding group of advanced scientists and its vocationally trained labour force by greatly expanding its training facilities for technicians of all sorts. American industry and government joined in offering grants to attract a larger proportion of university students into engineering and scientific fields. Newly industrializing countries such as India and China devoted substantial amounts of their comparatively limited resources to the development of a corps of technicians and scientists capable of leading their industrial effort.

The ever-changing process of industrial development brought first one type of labour into short supply and then another. At mid-century the shortage in both the industrially advanced and the newly industrializing countries was in engineers, chemists and other highly trained personnel. The introduction of such radically new techniques as the production of power in atomic reactors, for example, was directly dependent upon the rate at which the necessary atomic technicians and engineers became available.

4. *Clerical and administrative personnel*

A fourth group of workers became increasingly necessary as industry became more highly organized and complex and more geared to a mass market. These were the clerical and administrative staffs who were cogs in the organizational machinery through which industry was carried on and who manned the services on which it depended. From file clerks to managers they made up an industrial bureaucracy of office workers, salesmen, accountants, advertising men, bank clerks and supervisors that absorbed a growing proportion of the labour force of industry. Although automatic record systems and computing devices took over many routine white-collar tasks, the organizational as against the physical aspects of industry continued to require a large and growing number of workers.

For this part of industry's labour requirements the essential qualifications were general education combined with specific skills such as stenography or accounting and with qualities of personality and understanding of human relationships which their responsibilities involved. To meet these needs the curriculum of general secondary schools in many places was expanded to include a variety of commercial courses, and separate commercial schools specialized in this type of training. Schools of commerce and business administration at both secondary and university levels offered technical training in such subjects as accounting and administration, together with a programme of general education featuring the social sciences.

5. Recruitment of labour force

In order to recruit labour and bring the available worker together with the available job, industrial countries developed employment services and programmes for vocational selection and guidance. They also set up safeguards against abuse of workers in the recruiting process. In the industrializing countries safeguards were less adequate and only a beginning was being made toward establishing employment services.

In the early stages of industrial development and continuing to a very considerable degree in most countries, the labour force for expanding industry drifted into the localities where it was needed in an informal manner as news of new opportunities travelled to family members, friends or neighbours. The great bulk of rural–urban migrants in each country, and the millions of European peasants who sought new opportunities overseas, changed their locality and found their places in industry in response to general rumours of opportunities and personal information from those who had gone before.

Employers in their turn depended upon word of mouth, from old to new employee, to recruit a large proportion of their workers. Sometimes a personal contact by employer or foreman supplemented the contact of old to potential worker, as when young Japanese girls were brought from rural communities to work for relatives or family connections in cities, or an Italian *padrone* contracted to supply a work gang of his compatriots for an American or Argentine employer.

As industry came to require a variety of special experiences or training, the informal hit or miss method of recruiting labour and finding jobs no longer sufficed. Private individuals, trade unions, professional associations and governments established employment services to enable employers to find suitable workers and workers to find suitable jobs. That this was no simple problem was evidenced by the fact that the International Classification of Occupations prepared by the International Labour Office in 1949 listed more than 50,000 separate categories of employment.

The impetus for the establishment of employment services came from quite opposite directions: from the need to meet the problem of unemployment and from the effort to cope with labour shortages in time of war. The oldest systems, those of Germany and Great Britain, owed their establishment to concern over unemployment. Several German municipalities established employment exchanges following the industrial depression of 1893–94; the British system, set up by Act of Parliament in 1909, was the outgrowth of a royal commission's study of unemployment. The labour shortage during the first world war, however, was what made the recruiting and effective placement of workers a matter of national concern and led to the establishment of public employment services in many countries.

At the close of the war the International Labour Organization at its first meeting in 1919 demonstrated how widely the need for employment services was accepted when it adopted a convention calling for the establishment by

each ratifying state of a system of free public employment agencies under the control of a central authority with advisory committees representing workers and employers. During the inter-war years thirty countries adhered to this convention and by mid-century thirty-three countries had ratified it, while a number of countries not adhering to the convention, such as Canada, Australia and the United States, also had established public employment services.

As employment services developed and functioned they continued to reflect their twofold origin. In countries which had schemes for unemployment insurance or assistance they were apt to be linked with this system, and the receipt of unemployment benefits was usually made dependent upon registration at an employment exchange and the acceptance of suitable work offered there; in a number of countries these services in themselves were the chief device for trying to deal with unemployment. At the same time the ever-shifting character of the labour market led some employment offices to serve as centres of vocational guidance, especially to young people and to older workers displaced when their skills became obsolete; in the latter role they undertook systematic studies of occupational requirements and trends and used performance and aptitude tests to determine the probable fitness of workers for particular occupations. In newly industrializing countries the principal need was for vocational guidance and training, to meet the critical shortage of skilled and technical workers and managerial personnel without whom there could be no employment for the mass of unskilled workers who drifted to cities much faster than jobs became available. The system introduced in the 1950s in Colombia, of interest to other Latin American countries, taxed all substantial employers to maintain a national labour training and recruiting service which made estimates of national requirements for trained workers and arranged with industries to offer needed types of training and to recruit candidates from among their employees.

Since employment services acted as intermediaries between workers and employers they were in a position to give priority to the interest of one or the other group—to try to find for employers the workers whom they most wanted or to find for workers the jobs which they most desired. The ILO convention called for advisory participation by representatives of both workers and employers in relation to the administration of the service. Workers however sometimes alleged that the prejudices of employers were allowed to dictate the choice of workers recommended by the service, while employers complained that the service forced upon them workers who did not suit their needs. The more the process of labour recruiting was placed upon an objective basis of analysis of the job to be done and the matching of qualifications to tasks, the more technical became the role of the employment services and the less likely to be biased toward the interests of either employers or workers.

Where the state dominated economic activity, and generally in time of war, recruitment of workers on a voluntary basis was supplemented by conscription or the freezing of workers in their jobs. In Nazi Germany certain

categories of workers in tasks essential to the rearmament programme were tied to their jobs. Young people in the USSR, who received training for the specialities that were in short supply, were routed to jobs where they were needed, and during most of the period under review workers in general were not allowed to quit their jobs without permission; in the period of intensive industrialization, numbers of criminals, especially offenders against the state, were shipped for corrective labour to mines or other distant places where conditions were especially hard and it was difficult to attract workers on a voluntary basis. In South Africa taxes which could only be paid by earning cash wages were used virtually to force Africans to work in the mines, and the system applied in Portuguese Africa was even more direct. Various limitations on labour mobility were imposed in some other countries in circumstances of labour stringency.

During the first world war few restraints were placed on the free movement of workers from one job to another, except in Germany and for some French soldiers sent to work in munitions industries, but in the second world war all the belligerent countries restricted the right of workers in critical types of employment to change their jobs and gave priority in hiring to industries associated with the war effort. The Nazis used several millions of forced slave labourers from occupied countries to man their war industries.

The general result of institutionalizing the recruitment of labour was to introduce into the process a rational system of study, job classification, objective determination of fitness and vocational development; but the system was very far from complete even where employment services had the longest history or the most ambitious programmes.

6. *Conditions of employment*

In all industrial and most non-industrial countries standards were established by law for the conditions under which labour might be used. The developing body of social and labour legislation in the different countries was both influenced by and reflected in the standards adopted by the ILO from 1919 onwards. These standards gradually became the norms for employment and conditions of work in countries all over the world.

Such regulations generally excluded young children from labour in industry and limited the employment of older children in dangerous trades; they regulated work of women in hazardous employment or at night; they provided codes for industrial safety, maternity protection and protection of workers' health; they limited hours of work and prescribed rest periods; they established minimum wages and in some cases principles of wage policy such as equal pay for equal work. In some countries where discrimination against certain classes of people was practised because of race, religion or other such factors, these discriminations in employments were forbidden by law. To carry out these regulations governments set up systems of labour inspection and administration.

(*a*) *Job tenure*. Within this framework, which evolved through the years, the industrial worker was employed for wages and normally worked and was paid only when the employer had a job which he wanted him to do. This manner of employment rested on the assumption that labour was to be bought on essentially the same basis as materials and would similarly enter into the direct cost of production. Employment of workers only for the time in which they were actually engaged in work gave flexibility to industry, permitting it to expand or contract, to vary from season to season, to shift from one kind of product to another, to change locality and to substitute machines for workers with a minimum of friction. For workers it meant basic uncertainty and insecurity of tenure.

In this situation employers and workers often sought different ends. Employers wanted to have a supply of labour available and they wanted labour to be mobile, ready to go where jobs were offered and to leave places where industry no longer needed them rather than to remain as a permanent burden; but they also wanted labour to be steady and reliable, not too ready to quit and seek another job. Workers for their part wanted a measure of security, freedom from the fear of being laid off and the necessity of moving away from their community in search of work; but they also wanted freedom to quit and to work or not work as they desired. When labour was scarce employers were especially anxious to hold on to their workers; when jobs were scarce workers were especially anxious to hold on to their jobs.

The trend during the twentieth century in the industrially advanced countries was toward greater stability of employment and job security for workers, assurance of a job for longer periods at a time, protection of job tenure and more careful and systematic use of workers by employers. Cyclical fluctuations in economic activity in the capitalist economies and technological displacement continued to threaten workers with loss of their jobs. But much of the day-to-day uncertainty which had first characterized industrial employment was modified or removed.

Increased job stability was one of the objectives of labour organizations. They insisted that the principle of seniority in dismissals and re-engagement be written into the collective contracts. They also sought guarantees of continuous employment, or at least of pay, for a longer period than the hour, day or week by which workers were customarily engaged. In the first quarter of the century such efforts brought little job security. As late as 1937 an American labour union in a mass-production industry numbered among its victories in a successful strike that the company agreed to lay off no worker with less than twenty-four hours' notice.

By mid-century, however, the situation had changed so radically that some of the leading American industries such as automobile manufacture and steel, under pressure of trade union demands for a guaranteed annual wage, agreed to assure workers the opportunity to work up to a specified number of weeks during the year or to pay the equivalent of their wages if no work was offered.

Industries on their own initiative adopted the practice of keeping their labour force continuously at work. The more elaborate and expensive their equipment, the greater the waste of allowing it to stand idle; the more they required trained and specialized workers, the less could they afford the cost of re-engaging and retraining them.

Governments also intervened to stabilize the worker's income and sometimes to place pressure on employers to regularize employment. Beginning with Great Britain in 1911, most of the industrially developed countries adopted some form of unemployment compensation by the state for workers who were dismissed from their jobs and were unable to find new employment within a short time. The original British scheme, and the first state unemployment compensation scheme in the United States, attempted to encourage employers to avoid fluctuations in their demand for workers by requiring a lower contribution to the unemployment fund from employers with stable records, or granting them a rebate. Later schemes in these countries and schemes elsewhere, however, taxed regular and irregular employers alike, since their purpose was to maintain workers' income and the causes of unemployment were largely beyond the employers' control.

(*b*) *Hours of work.* The length of day for which workers were employed was fixed by custom, the employer's choice, agreement between workers and employer or by law. Few workers were employed to work for less than the standard working day. Factory operations started and stopped at regular times and required a full complement of workers throughout the period, and industry was reluctant to employ workers on any other basis. Although many types of workers were available for part-time work—women with homes to care for, young people pursuing education, older or infirm workers with limited strength—they were only used by industry during wartime or other period of labour shortage, as a method of recruiting future technicians or in response to social pressure.

Standard hours of work in industry fell steadily during these years. Some labour unions from their earliest formation had worked to reduce hours below the period from sun-up to sun-down, which had been normal in the first part of the nineteenth century. By the opening of the twentieth century the ten-hour day and six-day week had been widely established, although industries which required continuous operation, such as steel, continued to work twelve-hour shifts, day and night. Organized workers all over the world were calling for reduction of hours to eight.

In the early years of the twentieth century, studies in the United States of the effect on production of workers' fatigue brought out the fact that up to a certain point workers actually produced more per day in some occupations if their hours of work were less and they were allowed rest periods. The results of these studies helped to reinforce the claims of workers who demanded the eight-hour day as a means of receiving, in the form of leisure, a share of the new wealth created by modern industry. Such claims had been put

forward by the First Socialist International in 1866 and by American and British trade unions in the same decade. The Second International had made it a major issue after 1888.

The eight-hour day was instituted for employees of the United States government in 1868 and in Australia and New Zealand it became general in industry before the first world war. The USSR made it standard immediately following the October revolution. When the International Labour Organization was established in 1919 the first convention which its joint body of

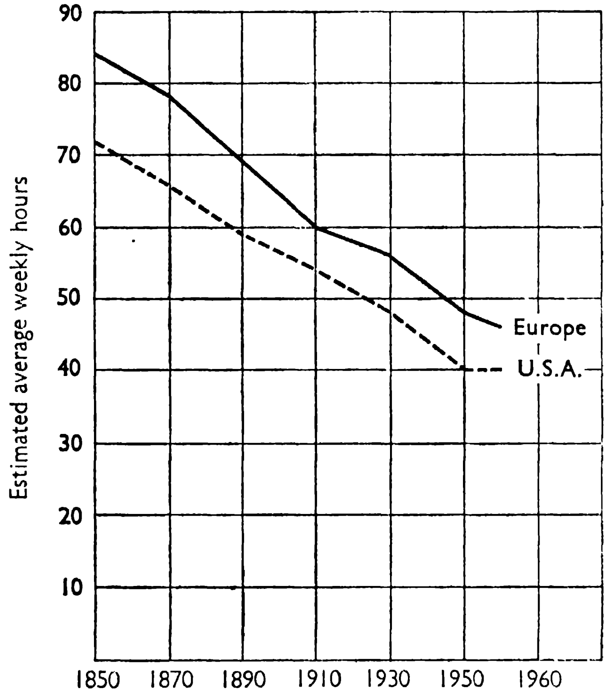


CHART XII. Trend in hours of work, 1850–1955. Europe and USA. Estimated Average Weekly Hours.

Source: Woytinsky, *World Population and Production*, p. 367; ILO *Statistical Supplement*, March 1962.

employer, worker and government representatives adopted and recommended to member states called for the eight-hour day and forty-eight hour week. In spite of widespread acceptance of the eight-hour day as a norm, however, a strike to abolish the twelve-hour day in the American steel industry failed in that same year, and not until several years later was the eight-hour day finally introduced in that industry.

Increased productivity, by permitting higher hourly wages, made shorter hours possible without reducing the workers' total earnings. As productivity continued to increase markedly in the succeeding decades, workers in

industrially advanced countries agitated for a further reduction to forty hours a week, usually in a five-day week, and the ILO recognized this norm in principle at its session in 1935. At mid-century, however, the eight-hour day and forty-eight hour week were still the prevailing norm in the majority of countries, although the world-wide movement for the forty-hour, five-day week was very strong. Collective agreements in a number of countries, notably Australia, Canada, USA and Great Britain, and in some other European countries, frequently specified the norm as forty-four or forty hours, with anything over that limit paid as overtime; in some countries, among them France, New Zealand and the United States, overtime was defined by law as over forty hours per week.

Once hours of work had been reduced to a point where the worker's health was not impaired and his productivity would not be increased by further reduction, the issue of still shorter hours became a question of the relative value of more leisure as compared with the additional goods which more work could produce. The International Labour Office attributed the strong continuing pressure for shorter hours to:

(1) the continuous rise of production and productivity, bringing with it higher material standards of living and making it easier to afford, at least in the more highly developed countries, any loss of potential output which shorter hours of work might entail, (2) the accelerated rate of technological progress which gained momentum as a result of war and post-war developments, and (3) a widespread desire for increased leisure; leisure needed for its own sake—to live in conditions of human dignity; and leisure required to compensate the stress and strain of modern industry and modern life.*

The world-wide trend toward shorter hours of work resulted in the establishment of the eight-hour day as a norm in the non-industrial as well as the industrial countries. As industry developed in these areas it was forced to adopt this general work pattern, in contrast to the pattern of long hours which had prevailed in the early days of industrial development in Europe and the USA. This provided an added pressure to use methods which would raise labour productivity even where the supply of unskilled workers was very great.

The same considerations which brought, and made possible, shorter hours also led to the introduction of paid holidays. At the opening of the century holidays with pay were the privilege of managers and some few salaried employees; they were virtually unheard of for industrial workers. By mid-century fifty-four countries had enacted legislation requiring the granting of paid holidays to workers of many types, and such annual holidays, as well as individual paid bank or festival holidays, were included in most collective

* International Labour Office, *Reduction of Hours of Work*: report to the governing body, 131st session, Geneva, 6–10 March, 1956, p. 2.

contracts. The practice of providing paid holidays for industrial workers, first introduced on a large scale in the USSR at the time of the October revolution, spread most rapidly after the second world war and there was a tendency to lengthen the period from one week to two or more.

(*c*) *Wages*. The wages which industrial workers received were determined by a combination of factors, chiefly the supply of available workers, the productivity of labour, the relative bargaining strength of workers and employers and the limits stipulated by law. These factors produced a wage structure which constituted the customary level and relationship among wages for different occupations and skills at any particular time and place. In European countries the wage structure ordinarily included a marked differential between the wage paid to men and to women.

The wages of unskilled workers were most likely to reflect the available supply and the provisions of law rather than productivity or bargaining position. Where there was a large flow of new workers from rural areas or when jobs were scarce and skilled workers dropped into the unskilled group because of depression or technological unemployment, there was little to prevent such wages from falling. On the other hand it was the wages of unskilled workers that most sharply reflected tight labour markets, for when jobs were plentiful these workers could leave lowest-paid employment for better positions.

The adjustment of the wages of unskilled workers to supply and demand was limited, however, by laws which set a minimum level below which no industrial worker could be paid. Such laws began to be enacted in the industrial countries before the first world war following the pioneer measures in Australia which inspired the British Trade Board Act of 1909. They became increasingly general in the inter-war years and were common throughout the world by the years after the second world war, though many workers remained unprotected by them. Minimum wage laws were based on the assumption that industry should not be allowed to use workers without paying them at least what was presumed to be needed for their own and their family's survival, although the level established was often closer to the rate which reflected supply and demand than to one based on worker's needs.

The wages of skilled workers were most frequently set by collective bargaining, for it was among such workers that trade unions took root earliest and most firmly, especially in Great Britain and countries with similar labour movements. In some countries and industries the effective organization of skilled workers on the basis of their trades enabled them to bargain collectively for substantial wage increases and to establish a wide differential between the earnings of such workers and of unskilled and semi-skilled operatives.

In the course of the half century the general level of wages in all the industrial countries rose markedly, reflecting the great increase in productivity during these years. In spite of sharp fluctuations downward in time of depression and upward in time of labour shortage, the trend of real wages,

adjusted for change in the prices of things bought by workers, was upward over the years. Precise comparisons between years and among countries are difficult because of changes or differences in the items bought by workers, the length of the work week, taxes withheld from wages, the socially provided goods and services available to workers which did not have to be charged against their wages, and the groups of workers included in the computation. But there can be no doubt that the trend was present and was shared in varying degrees and forms by all industrial countries.

The greatest proportionate increase came at the bottom of the wage scale, as the combination of minimum wage laws, the elimination of many unskilled tasks by machines, the spread of union organization to unskilled as well as skilled workers, and the period of high labour demand during and after the second world war combined to raise the wage floor. As a result the gap in wages was narrowed as between skilled and unskilled jobs, traditionally low-paid and higher-paid industries, and men and women. The wage difference between skilled and unskilled workers in machine making, printing, electric power and construction in the principal industrial countries exclusive of the USSR in 1954 amounted on the average to approximately 20 per cent. In 1938, when employment had been slack, skilled wages in these industries had averaged 25–40 per cent above the unskilled. Some industries, such as textiles, clothing or tobacco manufacturing, were and remained low-wage industries as compared with such industries as petroleum, metal products or automobile manufacture, partly because their labour force included a larger proportion of unskilled workers or women. But though average wages in the high-wage industries continued to be one-third to two-thirds higher than those in the low-wage group, more than double in the case of Japan, the difference at mid-century was less than it had been before the second world war. Women's wages too were coming closer to those of men, partly because women were entering a wider range of better paid jobs and partly because the movement for equal pay for equal work was gaining momentum. In most countries at mid-century, however, the average earnings of women in industry were still only about two-thirds of those of men and different rates for similar jobs still remained common in some fields.

Wages were paid to industrial workers on the basis of the time worked or the work done; they were paid in cash and in the form of a variety of benefits such as paid holidays and retirement and sickness allowances. Piece-rates designed to stimulate the efforts of workers to greater production were common in certain industries, such as clothing manufacture, where the individual could affect the amount of production by his own effort and where his contribution to production was clearly measurable. In highly mechanized processes, where the rate of production was determined by the machine and the exact contribution of one worker could not be distinguished clearly from that of another, piece-rates were less applicable and payment on a time basis prevailed.

In the period under review conflicting factors influenced the trends in methods of wage payment. The effort to achieve high productivity led to the adoption of incentive systems of pay. The USSR abandoned the policy of relatively equal time-rates which had been adopted in the early period of Soviet administration in favour of incentive systems which greatly favoured the highly productive worker. Some use was made of group incentive payments in that country but these were progressively replaced by individual payment based on the worker's output.

In European countries there was an increasing tendency to use incentive pay as industries strove to raise productivity during and after the second world war. In 1951 the ILO found that the various forms of payment by results in use in European countries were quite generally yielding both higher productivity and higher wages than comparable operations where workers were paid on a time basis. The proportion of industrial work performed at piece-rates or under incentive plans had increased in several countries since before the war, and amounted to more than half in Norway and Sweden, over a third in West Germany and Great Britain and 70 per cent in Hungary. Such systems, however, were recognized as tending to place workers under strain which could impair their health and efficiency.

In the United States incentive systems were strongly opposed by organized labour. Systems known as 'speed-up and stretch-out' had been introduced in the early part of the twentieth century in textile and other industries which, the workers maintained, placed them under excessive pressure by using the production of the faster workers as a norm and then re-defining the norm upward as the rest of the workers became geared to the new speed. Although the stretch-out practices had generally been abandoned by mid-century, trade union leaders in the United States remained almost unanimously opposed to incentive systems of pay. The workers who were under such systems, about a quarter of all wage and salary employees, were chiefly in the production of apparel, footwear, textiles, cigars and some special metal products, and in retail sales and repair, rather than in the major, highly mechanized industries. In the latter, wages were tied to productivity in general rather than to the production of the individual worker, as collective contracts came to provide for an automatic wage increase based upon the assumed annual increase in productivity of the industry as a whole.

In addition to cash wages workers received a variety of benefits which augmented their real income from work, although the extent to which these constituted a net addition depended on whether they were based in part on contributions by workers or were paid for wholly by employers or the state. The tendency was for these fringe benefits to multiply and to constitute an increasing proportion of the labour payment. Paid holidays, sick leave, pensions on retirement, accident compensation, medical services in the plant, often family allowances to supplement basic pay, recreational and educational facilities and day care for the children of women workers all supplemented the

worker's cash income. Among the members of the European Coal and Steel Community—Holland, Belgium, Luxembourg, France, West Germany and Italy—in 1953 these payments augmented the steel-worker's average hourly earnings by amounts ranging from 30 per cent in Belgium and Luxembourg to 52 per cent in Italy. Benefits and allowances were less in some other industries, but for French employers as a whole social benefit payments amounted to nearly 40 per cent of their total labour costs.

The effectiveness of all types of wage rewards as a means of drawing workers into the labour market, holding them there and stimulating their effective performance depended upon the cultural setting within which industry was carried on and the value placed by potential workers on money as against other things. In countries with a traditional non-money economy or limited wants, higher wages sometimes reduced rather than increased the willingness of the worker to work, for the worker could satisfy a limited desire for money in a shorter period and enjoy leisure or some other pursuit in the rest of his time. Mining companies in remote rural areas of Latin America, for example, found wage incentives ineffective in securing steady work until they stocked their company stores with products which appealed sufficiently to workers and their wives to provide an incentive to acquire more money. The imposition of taxes that could only be paid by cash earnings performed the same function in various parts of Africa. Where the things that workers wanted were in short supply so that money appeared of little use, as in some Asian countries, the provision of workers' housing was regarded as more effective than additional wages in making industrial employment attractive. Even in such countries as the United States, Australia and New Zealand, where a high material standard of living acted as a powerful incentive and the workers' desire for goods seemed unlimited, the desire for leisure offered a serious alternative to some, while others worked at more than one job to earn enough to satisfy their wants.

(*d*) *Working conditions.* The physical and psychological conditions under which work was carried on changed dramatically as technical changes in industrial processes made for both safer and pleasanter work-places. But factory employment continued to expose many workers to serious hazards. In spite of great improvements in factory design, replacement of moving shafts and belts by electric outlets and substitution of mechanical for human operations at many points of danger, industrial accident and disease continued to take a heavy toll.

Under the common law employers had been liable for injuries to their workers on the job only when they were sued and could be proved to be at fault. By the time of the first world war most industrial countries had taken steps to make employers legally responsible and to require them to pay compensation for work injuries. At mid-century the social security systems of more than forty countries included compensation for injury or death due to work accidents. Germany, with the oldest and most complete system,

required its employers to insure themselves against workers' claims in order to make sure that they could meet these obligations. Most United States employers were also required to be covered by insurance, as were the British coal operators.

Employers were thus placed under pressure to cut down accidents, since the cost for insuring themselves against accident claims was commonly based upon their safety record. Insurance companies developed a corps of specialists in accident prevention who provided consultation services to plant managers and conducted studies of accident patterns. Plant designers laid out new factories with the safety of workers as a central consideration. These measures brought spectacular reductions in industrial accidents in some industries and a general decline over the years in the rates of death and injury per number of workers employed. The actual volume, however, remained large. Though the overall death rate from industrial accidents in the United States was cut in half between 1913 and 1953, no less than 15,000 people were killed in the latter year and nearly 2,000,000 injured more or less seriously. In the 1950s approximately 3 per cent of the US labour force was involved in work accidents annually; the British rate had been reduced to 2 per cent while in Australia 9 per cent of all industrial employees suffered injuries. Industrial safety was coming to be recognized as a major problem in newly industrializing countries.

Many technical developments, moreover, increased the hazards to which workers were exposed, especially from injurious chemicals, dust and fumes, and added the hazard of industrial disease to that of work accidents. Special clothing to protect workers, devices permitting workers to operate controls from a distance shielded from contact with injurious substances, limited periods of exposure, wet-drilling and other measures to suppress dust and fumes, and careful instruction of workers in safety practices were used to guard workers from the consequences of industry's increasing use of substances harmful to man. The International Labour Organization sought to establish limits of safe exposure and to provide a guide for the framing of regulations and the adoption of measures to safeguard workers' health.

Still more serious, at mid-century, was the danger of radiation from the use of atomic energy, not alone in the nuclear reactors themselves, but in exposure to radioactive dust in the mining of uranium and to radiation in the plants for uranium refining, and in the handling, transport and use of by-products such as the radioactive isotopes which by the 1950s were already in widespread use in industry. The World Health Organization in 1956 offered a detailed programme for the prevention of radiation exposure, and the ILO brought together a group of experts in 1957 who drew up a comprehensive code of safety rules and practices for the protection of workers, wherever radioactive material was used. Various countries, notably France, were instituting training programmes for public health, engineering and administrative personnel. The problems in this area, however, still remained unsolved and extremely grave.

While these changes in the conditions of employment during the first half of the twentieth century substantially modified the life of the industrial workers, the nature of the industrial process itself remained basically unchanged. However generous the remuneration, whatever amenities might be provided to make the factory a safer and pleasanter place of work, and regardless of the economic system, industrial employment made the worker an instrument of production. It placed him under constant strain to keep up with the assembly line at the pace set and the time prescribed, whether he actually operated a machine or performed one of the other myriad tasks on which the vast, driving industrial mechanism depended. Efforts to humanize the industrial process could mitigate its impact on the worker but could not alter its fundamental character.

VI. MANAGEMENT

Industrial management supplied the momentum, organization and direction for twentieth-century industrial development. As industry became more complex, with larger units and a greater range and intricacy of interrelationships, the management process became more and more complicated and those responsible for it made up a growing proportion of the industrial labour force. The number of salaried employees in industry expanded in relation to the number of wage earners and a high and growing proportion of managerial, administrative, clerical and related workers in the labour force distinguished the more industrialized countries from those where industry was less developed.

The vital task of management was to bring together information, make decisions on the basis of such information, secure the execution of these decisions, evaluate results and build and maintain a working organization. Whatever the position of industrial management—whether operating for private gain or as the agent of a corporation, a co-operative body or the state—its drive, capacity for organization and decision, imagination, attitude toward innovation, ability to use the knowledge of many specialists and the resources of society, and its skill in relating its activity to that of others largely determined the effectiveness of the industrial process.

In the early stages of industrial development in the nineteenth century merchants who knew the markets and some men of technical ingenuity who also possessed organizational skill and speculative daring had provided industrial leadership, relying on rule-of-thumb procedures and shrewd guesswork. Twentieth-century industry required more systematic direction. Management practices were subjected to scientific analysis and study and, especially after 1920, management was developed into a professional field, with a body of principles and methods taught in schools of business administration, set forth in manuals and discussed in professional meetings and technical groups.

New and constantly developing techniques enlarged the scope and increased the precision of each area of management responsibility—choice of product, design and operation of the physical process of production, securing and using the necessary materials, machines, power and labour, selling or otherwise disposing of the product, financing the operations and building and maintaining a functioning organization.

1. *Choice of product*

For the obvious first step of determining what to produce, management needed to know the nature of the potential product, what it could do, and where and how it was in actual or potential demand. It had to decide what grades, qualities or types to produce and in what volume; and it had to determine continuously whether the product was still wanted, was profitable to make, could be improved, could be made more cheaply, and was preferable to alternative products which lay within the enterprise's capacity to produce. In the free economies which depended on the market, the technique of the market survey, which was elaborated and widely used in the second quarter of the twentieth century, provided a picture of potential demand which supplemented the flow of orders upon which producers had formerly depended for evidence of the demand for their goods. With the aid of rapid communication, record-keeping and computing devices, managers of large concerns kept before them a continuous picture of where their products were being sold, to whom and at what rate, and could note and respond to changes as they occurred. In planned economies, where the choice of what to produce and how much was determined by a central plan after consultation with the managements of particular units, the same type of information was helpful in proposing and determining future assignments and quotas.

It was not enough, however, for the industrial manager to decide what product should be made; he had to ensure that each unit produced would conform to specifications and be uniform in quality. In contrast to handicraft products which bore the imprint of the maker, it was the essence of mass production that identical products should be turned out in volume. When a customer ordered from a sample, he counted on receiving a supply that exactly matched, not an assortment of more or less close approximations. Standard specifications were necessary in order that the mass-production process could be set up and carried on, purchaser and seller could know that a transaction was clearly understood by the other, and materials, parts, screws or other products of one industry could be reliably used in the design of products by another and would fit when put together with products from other sources. The more complex and interdependent industry became and the more refined its products, the more necessary it became to establish standards, definitions and testing techniques in order to maintain quality control.

Prior to the first world war standardization was largely confined to the large companies which sought to take advantage of mass-production methods and

it was chiefly applied within the plant rather than on an industry-wide basis, although a few standards, such as the gauge for railway tracks, had been established and adopted as clearly essential. In general, producers offered a great variety of things which differed in no essentials, but varied sufficiently to make their combination impossible, such as electric light bulbs which fitted only certain sockets, or screws of the same thickness with many different threads so that nuts which fitted one bolt could not be used on another. Some cartels and trade associations started before the first world war to encourage concentration on standard items or agreed on standard descriptions of products made to certain specifications. The British Engineering Standards Association, founded in 1901, brought the first national approach to the development of standards and remained the only such organization and effort up to the first world war.

The impact of that war brought standardization into industry through the enormous demand for articles which met military specifications. By the close of the war the advantages to industry from the adoption of standards, both in reducing costs and increasing flexibility, led to the organization of national standardizing bodies in most industrial countries. Standards boards or committees were formed in Germany in 1917, the United States in 1918, Japan in 1921 and Russia in 1925. The first of a series of pan-American conferences on standardization was held in 1924 to facilitate international commerce within the Western hemisphere, and the International Standards Association was formed in 1926. First for basic materials and then for a wider and wider range of goods, standard dimensions were agreed upon, within countries and in some cases internationally, to permit interchangeability of parts, standard nomenclature was adopted to assure identification, standards of performance were defined in terms of such factors as resistance to abrasion, heat resistance or strength under pressure, standards of safety were formulated and standard tests were devised.

An important aspect of the movement for standardization was a reduction in the number and variety of products where such variety appeared to serve no useful purpose. A series of conferences between members of different industries and users of their products in the United States in the 1920s resulted in the elimination from mass production of some three-fourths of the varieties of common building materials and household furnishings; varieties of paving brick, for example, were reduced from 66 to 11, of woven wire fence from 552 to 69 and of the sizes of bed springs and mattresses from 78 to 4. In the years after the second world war a similar effort at standardization and simplification, especially for standard types of mechanical equipment, was intensified in the USSR and eastern Europe as part of the programme to raise productivity and bring a closer integration among these economies.

Standard specifications, nomenclature and tests provided industrial management with a device of major importance to the operation of industry, for they made possible a great increase in the rationalization of production and

conduct of trade. By mid-century a high degree of standardization had been developed within each of the industrially developed countries, but international differences persisted, including differences in measuring systems, and these impeded the flow of international trade, complicated management's task where an enterprise produced for both domestic and foreign markets, and presented serious difficulties to newly industrializing countries dependent upon imported equipment and faced with the problem of whose standards to follow in developing their own industrial designs. Differences in the voltage and rate of oscillation of the electric current supplied in different countries presented an increasingly troublesome problem as more and more industrial farm and household equipment was operated by electricity.

International military organization offered an incidental stimulus to international standardization among the western European countries. In the effort to secure effective communication and international interchangeability of equipment, the North Atlantic Treaty Organization set up a special department to promote standardization of procedures, military weapons and communications systems. This attempt at international standardization immediately encountered the differing national standards which governed many of the civilian items needed for military purposes.

2. *Production control*

Industrial management had to plan and operate the processes of production on the basis of knowledge of possible techniques, and choice of alternative methods and arrangements. Rational organization of industrial production was as vital to the high productivity of twentieth-century industry as machinery, power or other applications of technology.

All factory systems involved a flow of material through a series of steps timed to follow one after another. The task of production management was to refine this process with such accuracy of timing and precision in the successive steps as to avoid waste motion, delays, bottlenecks, idle workers or machines, materials or goods piled up at any point, breakdowns, waste of materials or excessive numbers of imperfect products.

Techniques for effecting these objectives were developed gradually and continuously in each specific industry, but major improvements affecting industrial processes in general were stimulated by such diverse developments as Frederick W. Taylor's methods of scientific management which were introduced in a number of factories in the United States after 1910, by Henry Ford's establishment of the assembly line, by Walter Rathenau's leadership in the rationalization of German industry in the first world war and by the Stakhanovite movement in the USSR.

Taylor introduced the practice of making careful detailed studies of the motions of workers and machines in order to determine whether changes such as the rearrangement of machines, adjustment in height of the workers' stools, or substitution of a horizontal motion for one requiring lifting or

stooping, would reduce the time required and lessen the workers' fatigue. He demonstrated to management and workers that each task consisted of a series of distinguishable, time-consuming movements which could be scientifically analysed and rationally planned and that such rationalization would speed up output, increase labour productivity, cut costs and permit the payment of higher wages. Henry Ford's assembly line added the feature of the continuous flow. Walter Rathenau brought standardization and simplification of procedures from top to bottom in the management process. Stakhanovism enlisted the active and alert attention and creative imagination of worker, foreman and manager in the continual process of seeking more rational and efficient arrangements and design.

The key to successful production was the continuous flow, whether in a skyscraper being built in a crowded city street where materials had to be used as fast as they arrived, an automobile plant where hundreds of different materials and parts entered the plant at one end and were driven away as finished cars and lorries from the other, a shipyard where prefabricated parts were assembled on a waiting keel, or a meat-packing establishment where animals entered the plant and emerged as meat, hides, glue, fertilizer, shortening, bristles and a dozen other products. The production manager's basic guide was the flow chart which provided the plan and the basis for detecting bottlenecks.

The great precision in production flow was made possible by quick methods of communication, both within the plant and with suppliers of materials or receivers of finished goods, by transport systems which could be relied upon to deliver on schedule, by accurate and systematic recording devices which made it possible to know what was happening at any moment and to study past records for evidences of imperfections in the flow, and by calculating mechanisms which made it possible to examine the interaction of a multitude of factors. As electronic computers began to be used they immensely increased the range and intricacy of the interrelations which could be analysed, and they revealed possible economies which slower and more partial methods had been unable to suggest. In some plants the introduction of closed-circuit television which enabled the production manager to keep the production process continually in view provided an additional means of detecting flaws in the system.

3. *Personnel administration*

Good labour relations and increasing labour productivity were essential to effective operations and a test of good management. The majority of employers in most industrial countries were slow to adopt a rational and co-operative approach toward their labour force in the early years of the twentieth century. They clung to the idea that low wages were the way to keep down labour costs and that labour organization and collective bargaining threatened their control and ability to maintain this policy.

Management interest in ways to increase labour productivity began to grow when the scientific management movement showed the possibilities for raising productivity through careful job analysis; Henry Ford's deliberate policy of high wages, short hours and systematized work brought high profits with low prices; the establishment of labour-management committees in British, German and American factories during the first world war proved fruitful in meeting the increased production required by war.

Labour unions were initially suspicious of this interest on the part of management, for they feared that it would take the form of pressure on workers to increased exertion without increased pay or would lead to technological displacement. But where unions succeeded in securing acceptance from management and where good working relations replaced mutual antagonisms, they sometimes undertook time and motion studies of their own in order to be in a position to negotiate with employers over the workers' share in the fruits of increased productivity. Some unions, in fact, took the initiative in recommending improvements in work organization, in order to enable their employers to stay in business in the face of competition or declining markets, or to expedite a changeover from civilian to military production, as did the clothing workers' union in the United States in the depression of the 1930s, and the automobile workers' union at the beginning of the second world war.

Studies of worker efficiency in the 1920s and 1930s, especially those by Elton Mayo at an electrical manufacturing plant in Hawthorne, USA, brought out the importance of psychological factors and added a new dimension to personnel management. Since these studies were conducted by industrial engineers who were engaged in the training of business managers, they entered quickly into the thinking of leading industrialists and led to the establishment of personnel departments in large concerns, the training of men to conduct these departments in the light of the latest psychological knowledge, the training and retraining of supervisors, the establishment of systematic personnel practices with respect to such things as rest periods, sick leave, job tenure and promotions and, in some large companies, to educational programmes, recreational opportunities and a variety of social services. Additional studies sought evidence as to the most effective ways of conveying instructions to workers and receiving suggestions from them, and of maintaining worker morale, interest in the job and loyalty to the concern.

In some countries and industries labour management committees functioned in respect to various aspects of the enterprise's operation, and elsewhere less formal methods of consultation and joint agreement on matters within the plant were maintained. Management and labour joined in carrying out terms agreed to in collective contracts and in making the machinery for settling grievances or disputes work smoothly. Although personnel management differed greatly among enterprises and from one country to another, ranging from paternalism to indifference, from co-operative relations with organized labour to bitter antagonism, and from the persistence of sharp class

lines and cultural differences to the blurring of such distinctions, management policies and methods in industrially developed countries were increasingly designed to achieve high labour productivity by recognizing workers' needs and stimulating their response as human beings.

By the close of the second world war rising productivity was accepted by management and labour alike in the industrially advanced countries as necessary to their own and their nation's welfare. This recognition of common interest did not by any means eliminate the conflict and often antagonism between management and labour over their respective shares in the fruits of industry. But it did become a basis for collective bargaining negotiations and for the fixing of wage structures and other conditions where, as in the Scandinavian countries, these were arrived at by nationally established procedures.

In the United States, following the lead of the United Automobile Workers' contract of 1946, wage contracts began to call for an annual wage increment designed to pass on to the workers automatically a portion of the expected increase in productivity. In the decade following the war productivity teams composed of workers and employers from one or another industry visited other countries, chiefly coming from European countries to the United States, with a view to sharing the experience gained in raising output. Of the fifty-eight British productivity teams which visited the United States, three-fourths cited the workers' appreciation of the need for higher productivity as one of the reasons for the high level of productivity in America and half mentioned the progressive attitude of management.

The joint interests of labour and management in increased productivity were put to a severe test by the accelerated rate at which new automatic processes were introduced, for the large displacement which could result from a single, complex computing device brought great uncertainty as to the full impact of these changes on workers and how benefits from the resultant effects on productivity would be shared.

In the Soviet Union, and countries following its economic and technical lead, a principal means of organizing the productive process and stepping up productivity was to set production goals which would be met and if possible exceeded. Workers were encouraged to devise means to exceed their quotas or to suggest improvements, and were rewarded and honoured for so doing. The role of trade unions was to assist in the meeting of production goals by helping to train workers for their tasks, and by maintaining work morale and discipline. A variety of devices such as group competition between sections of a plant or between plants, public display of production records of individuals and groups, and the stimulus to productive effort offered by five-year plans and other national or local objectives all served to enhance the productivity of the labour force.

Yugoslavia counted on the workers' interest in success to maintain and increase productivity. The direction of enterprises was in the hands of workers'

councils with authority to choose whether to use the earnings, after taxes, for reinvestment, social expenditures or direct bonuses to workers.

Both in capitalist and communist economies the second quarter of the twentieth century thus saw a growing tendency to treat workers as partners in industry rather than merely as tools, to humanize work and to transform the worker from an item of cost into an active participant in the productive process. The process was far from complete and in most places there remained undercurrents of labour strife, but the tendency was nonetheless real.

This trend was formalized in various types of management-labour co-operation throughout the industrially active parts of the world. By 1950 twenty-nine countries, including nearly all European countries, both western and eastern, whatever the form of their economy, had well-established systems of management–worker co-operation in single enterprises, in industries or on a national basis, while less comprehensive forms of such co-operation existed in another half-dozen countries. Some of these systems owed their initiation to wartime patriotism and the danger of wartime sabotage; some were established contractually and others by legislation; they often reflected social as well as economic objectives and used social means to achieve economic goals. The object of all such systems, according to the ILO, was to unite the different elements engaged in production in the common task of raising social standards by a continuous increase in productivity.

4. *Merchandising*

Mass-production industry was as dependent on mass methods of distribution as on the production line itself; the industrial manager had to choose his merchandising methods and keep a constant check on their results.

The flow of goods to the consumer through the channels of distribution had to be as streamlined as the flow of materials through the assembly line in the plant. Devices for systematic recording, swift communication and automatic computing played the same role in mass merchandising as in control of mass production. Methods of selling which had served to distribute a relatively small number of items to a relatively small segment of the population were wholly inadequate to the task of routing masses of products to masses of people.

Mass merchandising, like mass production, involved breaking down the total process so that it could be performed in a series of simple steps by relatively unskilled persons, and then substituting where possible an automatic operation for unskilled labour. Towards this end, products were sold in packages which carried their own description and sales appeal and did not depend on the salesman's detailed knowledge of the merchandise or ability to convince the buyer; brand names were used as a means of identification and appeal. Mail-order companies reached millions of buyers with catalogues which earned the name of 'wish books'. 'Five and Ten Cent' or 'Uniprix' stores offered many common, small, low-priced items, or other products put

up in small amounts to sell for a standard low price. Self-service stores stocked with clearly marked items required only someone to place products on the shelves and someone to add up the customer's purchases and take his money. Automatic vending machines dispensed such things as cigarettes, candy, bottled beverages, milk, handkerchiefs or stockings, in public places such as railway and bus stations or factories. Some business concerns built up a selling organization to reach the public directly or by means of agents; others sold only through intermediaries.

Mass consumption required that the potential consumer should know about and desire the product; advertising provided the link between mass production and the mass market. The more plentiful and varied the supply of industrial products became—the more affluent the advanced industrial societies—the greater the use of advertising to stimulate and guide consumption, and advertising became as high-powered and systematized as the other processes which were part of industrial management. While the primary function of advertising was to inform the buyer, and governments made efforts to hold advertisers to that function or at least to check false and misleading claims, the aim of high-powered advertising became increasingly to influence and not merely to inform. Using every modern medium of communication to attract attention and interest, advertisers sought to arouse the desires of the people for the products of industry.

In planned economies there was not the same need to press products on to the market, but choices among possible methods of distribution still had to be made. During the period under review, when production in the planned economies was heavily concentrated on producers' goods, the principal problems related to methods of allocating the limited supply of consumer goods. As these economies became more affluent, new problems of distribution began to appear.

5. *Financial management*

The problems of financial management grew in complexity along with the physical aspects of production and distribution. Both in capitalist economies where management was under the necessity of showing an eventual profit or going out of business, and in planned economies where financial as well as physical balances had to be maintained, management needed to translate physical operations into financial costs and returns.

The tools of financial management were largely the same as those of physical management and their use went hand in hand. Detailed analysis of the physical processes of production and distribution provided the essential basis for detecting detailed costs that might be modified, and instruments for recording, analysing and computing intricate physical relationships were equally useful for financial accounting.

The need for elaborate systems of cost accounting gave rise both to a distinct profession of accountants, trained in their discipline and licensed to

practice, and to the design and construction of ever more elaborate business machines.

Accounting had already been recognized as a specialized skill in western Europe and the United States by the latter part of the nineteenth century. In the first quarter of the twentieth century professional associations of accountants in these countries established criteria for training and competence to qualify for the title 'certified public accountant'. Industrial managers depended on the technical knowledge of these specialists to analyse the financial aspects of their operations, to design and set up systems for keeping necessary records and supplying a continuous financial picture, and to review and audit their accounts periodically.

Mechanization of the financial processes began in the last quarter of the nineteenth century with such early devices as the typewriter, cash register and comptometer. As these and other machines for duplicating, calculating and tabulating were introduced, the clerks who had laboriously copied information and entered it by hand in the ledgers of nineteenth-century firms were replaced, first by a battery of typists who made simultaneous copies of each record, subsequently by punch card operators who punched coded information on cards which sorting machines analysed and tabulated automatically, and then by electronic systems which noted, stored, computed and reported information as desired. The use of business machines was accelerated phenomenally in the decade after the second world war, as may be seen in the experience of the world's leading manufacturer of business machines which quadrupled its sales from 1945 to 1955 and increased the number of engineers in its employ more than twelvefold.

6. *Organization*

Industrial management had to build and maintain going organizations which grew in size and complexity as the scope of industry widened. The scale of production resulting from modern technology required the creation of a joint stock company, government enterprise or corporation, co-operative body or other large structure.

The effective operation of an industrial bureaucracy presented many of the same problems of form and administration as were encountered in government agencies and other large bodies. It involved problems of authority, responsibility and motivation, and the need to assure that efforts by members of the organization to attain their own goals would contribute toward the objectives of the organization as a whole.

In view of the growing importance of large-scale organization in modern life, much systematic study and experiment was carried on in an effort to understand more clearly how to build an effective organization and maintain its vitality. Studies of organizational structure analysed such problems as the proper relation between the function to be performed and the authority and responsibility of the person assigned to perform it. They distinguished

between the staff functions of providing information and advice and the line functions of making decisions and issuing directives. They considered the number and kinds of people who can be effectively supervised directly by a single individual, and evaluated the need for subordinate divisions, the effective balance between centralization and decentralization and alternative bases for forming departments or other units. Studies of the processes which take place within an organization dealt with such matters as how decisions are actually reached and what conditions favour a sound decision-making process. They observed group interaction taking place within committees, conferences or staff groups and tried to determine the size, composition and method of conducting a group which was likely to stimulate its members and further its purposes. They sought means of effective communication, in order that directions and suggestions might be given in such a manner as to be heard accurately and fully understood.

As the findings of these studies were assimilated by industrial management through formal study in schools of business or public administration, conferences, or inquiries on the job, the task of industrial management came to be seen more and more clearly as one of human relations. It was one of the ironies of the twentieth century that the more technology extended the power of man over nature and spread mechanization, the more crucial became the factor of human relations to those engaged in the conduct of industry.

VII. THE PRODUCTS OF INDUSTRY IN MODERN LIFE

The new products of industry, many of them unknown or not in use at the opening of the twentieth century, transformed the daily life of the people of industrial countries and of those in the urban centres of non-industrial parts of the world. Merely to enumerate the broad categories of products and the areas of life which they touched would be beyond the scope of this chapter. Motor vehicles not only provided unheard of mobility but placed ordinary individuals, at the wheel of a car, in command of tremendous power and in constant jeopardy on the road. Communication devices—telephone, radio, television—placed the home in contact with distant places and brought into the home all manner of information, experience and ideas. The gramophone made the best as well as the most popular music available anywhere. The cinema not only offered a principal form of mass entertainment but set new styles, undermined old habits and opened new horizons. The high-speed camera captured events and people around the world. Improved lighting and heating brought increased comfort into daily life, while refrigeration helped to make foods available the year round.

The housewife's tasks were expedited and lightened. She was enabled to prepare nutritious meals and keep the home clean and comfortable with the aid of a multitude of household appliances, such as refrigerators, vacuum cleaners, washing machines, gas and electric stoves, automatically operated

heating and air-conditioning devices. New materials based on glass, cement, plastics, treated wood or composition boards entered into house construction; plumbing systems contributed to sanitation. Clothing materials made from artificial fibres could be washed and quickly dried without pressing. From the chemical industries came a variety of paints, lacquers and other surface protectors against weather or corrosion, together with dyes, drugs and detergents. A multitude of canned, frozen and dehydrated foods offered a varied diet and reduced the time for food preparation.

The small motor, both electric and petrol powered, served many purposes in the home and on the farm as well as in industry, operating a variety of tools and appliances, pumping water or fuel, running boats, fans, gramophone turntables, lawn mowers. Tractors and other power on the farm lightened the farmer's tasks. An endless array of objects and devices, small and large, for utility, amusement or adornment, were used in all walks of life.

Some people regarded the mass of industrial products as a burden and overlay upon the life of mankind, with life becoming standardized and man a slave to his gadgets. Some looked nostalgically towards the past while others insisted that more human values were associated with a simpler way of life and questioned whether material advance brought additional human happiness or merely added pressure, diversion and confusion. Proposals were even made that the process of invention be arbitrarily halted for a period in order that social institutions and man's ability to live with his new powers over nature might have a chance to catch up.

But the large numbers of people who inhabited the great urban areas of the world could not live without the resources which industry had brought them, and even those who withdrew to a simple life away from the pressures of industrial society depended on many of its fruits for their survival. The products, organization and processes of modern industry had become inextricably interwoven with the life of a large segment of mankind.

Yet one vital question remained: in an affluent society would man be able, and would he be inclined, to look on his material well-being as a means to a richer human life and not merely as an end in itself?

NOTES TO CHAPTER IX

1. Academician A. A. Arzumanyan writes: The economic competition over the last decade between the Soviet Union and the United States, between the socialist and capitalist world systems, has led to a radical shift in the balance of forces. Socialism has entered upon a period in which its power is steadily expanding, while the general crisis of capitalism is becoming increasingly severe. Capitalism is being edged out by socialism, and is losing one position after another to its rival.

The new stage in the general crisis of capitalism is characterized by a narrowing of the gap between the Soviet Union and the United States.

The Soviet economy is developing far more rapidly than that of the United States. Over the seven years 1954–60 industrial output in the USSR rose by an average of 11·1 per cent per annum, while that of the USA rose by 2·5 per cent. The socialist world system as a whole is also growing much faster than the capitalist world. Over the last ten years industrial production in the socialist system as a whole rose by an average of 13·6 per cent per annum, whereas the corresponding figure for the capitalist countries was 5 per cent. At the present time the industrial output of the socialist countries accounts for approximately 36 per cent of world output, as compared with 27 per cent in 1955.

Socialism is surpassing capitalism not only in rates of growth, but also in the absolute increase of industrial output. Between 1953 and 1960 the average annual absolute increase of total industrial production was approximately twice as great in the USSR as in the USA. In 1950 Soviet industrial production was about 30 per cent that of the United States, whereas now the figure is more than 60 per cent.

Academician E. S. Varga draws the same conclusion: In its pace of economic growth the Soviet Union has left the capitalist world far behind, and despite the heavy blows dealt to its economy by the civil war, the intervention, and the second World War, is now firmly established as Europe's largest, and the world's second largest, producer of industrial goods (E. S. Varga, '40 let rosta sotsializma i upadka kapitalizma' ('40 Years of the Growth of Socialism and Decline of Capitalism'), in *Novoye Vremya* (New Times) 1957, No. 4, p. 5). The United Nations data support the point of view of the Soviet scholars, and provide evidence of the low rate of growth of most of the principal capitalist countries.

See also Note 1 to Chapter XXI.

2. *On this question the Author-Editors would like to add the following material:*

The tables below, prepared by the United Nations in an attempt to show comparative rates of economic growth during the decade of the 1950s, are the most nearly comprehensive series available for any period. They have been rearranged in declining order of reported rates of growth. The United Nations reports the communist countries separately because their basis for calculating growth differs substantially from those used by other countries. The former exclude economic activities not contributing directly to material production, such as public administration and defence, personal and professional services and similar activities. There are no comparable figures for the non-communist countries making the same exclusions, and therefore there is no way of telling how the comparative figures here reported would differ if converted to the same base.

For the non-communist countries, average per capita income in 1958 is also indicated. It will be noted that the countries of relatively high per capita income show growth rates during this period of about 4 per cent or less, with the exception of the German Federal Republic and Iceland. Middle and low per capita income countries vary widely in their rates of growth. No corresponding per capita income figures are available for the communist countries.

AVERAGE ANNUAL RATES OF GROWTH OF REAL GROSS DOMESTIC PRODUCT, 1952–60,[1] AND PER CAPITA GROSS DOMESTIC PRODUCT IN 1958[2]

Country	*Period*	*Percentage rate of growth* Total	*Percentage rate of growth* Per capita	*Per capita product in US dollars, 1958*
		%	%	$
Israel	*1952–60*	*9·6*	*5·8*	*579*
Japan	*1954–60*	*9·5*	*8·4*	*285*
Trinidad and Tobago	*1952–60*	*9·2*	*6·0*	*529*
Algeria	*1952–57*	*8·8*	*6·4*	*220*

Country	Period	Percentage rate of growth Total	Per capita	Per capita product in U S dollars, 1958
		%	%	
Jamaica	1954–59	8·0	6·3	357
Taiwan	1952–60	7·5	3·7	114
Germany, Fed. Rep.	1952–60	7·2	6·0	920
Venezuela	1952–60	7·2	3·1	715
Puerto Rico	1952–60	6·5	5·7	581
Greece	1952–60	6·2	5·2	307
Brazil	1952–60	6·0	2·8	252
Rhodesia and Nyasaland	1955–60	6·0	3·4	161
Italy	1952–60	5·9	5·4	493
Austria	1952–60	5·8	5·6	656
Philippines	1952–60	5·7	2·4	192
Iceland	1952–59	5·6	3·4	946
Guatemala	1952–60	5·4	2·4	164
Thailand	1952–60	5·2	1·7	77
Portugal	1953–60	4·9	4·2	212
Netherlands	1952–60	4·8	3·4	767
Korea, Rep.	1954–60	4·8	2·5	104
Finland	1952–60	4·7	3·6	751
Ecuador	1952–60	4·7	1·4	180
Turkey	1952–60	4·7	1·8	201
Burma	1954–60	4·6	3·4	51
Nicaragua	1952–59	4·6	1·2	220
Colombia	1952–59	4·5	2·2	301
Cambodia	1952–58	4·3	1·6	86
Congo (Leopoldv.)	1952–58	4·2	2·0	87
France	1952–60	4·2	3·4	1089
Indonesia	1952–58	4·2	2·2	69
Switzerland	1955–58	4·1	2·8	1338
Sweden	1952–60	3·9	3·2	1309
Malaya, Fed.	1956–60	3·9	0·7	218
Denmark	1952–60	3·8	3·1	975
Nigeria	1952–56	3·7	–	81
Norway	1952–60	3·4	2·4	1012
Honduras	1952–59	3·4	0·4	192
Canada	1952–60	3·3	0·6	1767
Luxembourg	1953–58	3·3	2·6	1332
Chile	1952–59	3·2	0·9	352
Cyprus	1952–60	3·0	1·2	410
India	1952–59	3·0	1·3	67
Peru	1952–57	3·0	0·7	150
Ceylon	1952–59	2·9	0·4	122
United Kingdom	1952–60	2·7	2·2	1084
U S A	1952–60	2·6	0·9	2324
Pakistan	1954–60	2·6	0·5	54
Belgium	1952–59	2·6	2·0	1093
Argentina	1952–60	1·9	0·2	476
Syria	1954–60	1·7	−2·2	144
Ireland	1952–60	1·4	2·0	472
Paraguay	1952–60	1·4	−1·0	126
Morocco	1952–60	0·9	−1·9	159

AVERAGE ANNUAL RATES OF GROWTH OF REAL NET MATERIAL PRODUCT

Country	*Period*	*Percentage rate of growth* Total	Per capita
		%	%
China (Mainland)	*1953–58*	*12·6*	*9·5*
USSR	*1952–60*	*9·9*	*8·0*
Yugoslavia	*1953–60*	*9·3*	*8·1*
Bulgaria	*1954–60*	*8·4*	*7·3*
Rumania	*1952–60*	*8·3*	*6·9*
Poland	*1952–60*	*8·0*	*6·1*
Czechoslovakia	*1952–60*	*7·0*	*6·0*
Hungary	*1952–60*	*5·5*	*4·8*

The figures shown in these tables are computed as average annual geometric rates of growth expressed in percentage form for the periods indicated. They are based on the estimates of real gross domestic product or of real net material product which appear for the individual countries elsewhere in the same Yearbook. *Conceptual differences and other details concerning the basic data are indicated in the country tables. It should be noted that the methods used to obtain estimates of gross domestic product at constant prices and the years to which these prices relate vary widely between countries. The concept of material product used by the countries with centrally planned economies relates to the total value of goods and productive services, including turnover taxes, produced by the economy in the course of the year. The industries covered are generally agriculture, mining, manufacturing, construction, transportation and communication, trade and catering. Economic activities not contributing directly to material production, such as public administration and defence, personal and professional services and similar activities, are not included.*

In order to minimize the influence of single terminal years on the computed growth rates, the estimates of real product were averaged and centred for the first three and last three years of each period for which data were available, for example, the figures shown for the period 1952–60 represented rates of growth based on estimates of average real product in the periods 1951–53 and 1959–61.

(2) With respect to the statistics of per capita product in US dollars, the estimates in this table should be considered as indicators of the per capita *production of goods and services of the countries represented and not as measures of the standard of living of their inhabitants. No particular significance should be attached to small differences between the estimates of two countries because of the margin of error inherent in the method of estimation.*

Source: United Nations, Yearbook of National Accounts Statistics, *1962, Table 2a, 2b and 3*

Professor L. M. Gatovsky writes: In all countries engaged in the construction of socialism the process of industrialization has a number of features in common: the socialist nature of industrialization; a planned economy; high rates of growth; resources obtainable by utilizing the advantages of socialism; the development of socialist emulation, and others besides. At the same time there are also certain differences in the process of industrialization connected with the economic, political and natural geographical conditions in each particular country, its level of industrial development, science and technology, the structure of industry, productive capacity, existence of cadres of skilled workers, the role of foreign trade, etc. In the People's Democracies the concrete forms of industrialization and the rates of growth differ in many ways from the forms and growth rates that characterized socialist industrialization in the USSR—which at that time was the only socialist country in existence, and was compelled to create in the shortest possible time a first-class industry able to supply the economy with all the manufactured goods it required. . . .

All the People's Democracies benefit by economic and scientific-technological aid from the USSR and the entire socialist camp, and obtain a great economic advantage from the international socialist division of labour. The People's Democracies need not therefore develop their industries at such an intensive pace as was adopted in the

USSR, and do not have to set themselves the task of manufacturing products of all kinds (only China faces the problem of building an entire system of new branches of industry). Each country has the opportunity to develop those branches of industry for which economic and natural conditions are most favourable. To a greater extent than was possible in the USSR during the period of industrialization they can take into account the economic efficacy of investments in human and material resources. (L. M. Gatovsky, 'Ob obshchikh zakonomernostyakh i osobennostyakh stroitelstva sotsializma v razlichnykh stranakh' ('On the general laws of development and the specific character of socialist construction in different countries'), in: *Mirovaya sotsialisticheskaya sistema khozyaystva* (The Socialist World Economic System), Moscow: Gosplanizdat, 1958, pp. 67–8.)

4. Doctor of Economic Sciences A. A. Manukyan writes: The length of the working day, wage rates, etc., are determined by the struggle of the working class and the existing social system, rather than by the level of labour productivity. As the American Senator Paul Douglas remarked: 'I grew up in New England and I know the cotton mills and woollen mills of New England prior to the coming of unionism paid extremely low wages and worked extremely long hours.' (Trade Agreements Act Extension, Hearings before the Committee on Finance, US Senate, 85th Congress, 2nd Session, June–July 1958, pt. 2, Washington, p. 1071). It may be added that in the Soviet Socialist Republic the 8-hour working day was introduced in 1917, whereas in 1919, in the USA, a country with a higher level of labour productivity, a strike for the 8-hour working day was cruelly suppressed.

5. Doctor of Economic Sciences A. A. Manukyan writes: Prior to the twentieth century, and to a certain extent even prior to the end of the first quarter of the twentieth century, industrial development was in essence the achievement of Europe alone—first and foremost of Western Europe and the Eastern part of North America and also Japan. Outside these territories there were only small islands of industry, mainly the manufacture of textiles or mining, situated at great distances from one another, almost lost to view amidst the endless spaces of countries completely untouched, or barely touched, by industrial development.

   The history of industrial production thus affected directly only a tiny minority of mankind. It was only from the 1920s onwards that the greater part of the human race began to be involved in industrial development.

   The reason for this development of industry—within the limits of a few favoured countries—lay in the fact that under capitalism whole continents of colonial, dependent and semi-dependent countries were methodically converted into sources of raw materials and markets in which the metropolitan countries, pursuing their own interests, could dispose of their products. Through the very nature of its social and economic organization capitalism does not facilitate the general unlimited development of industry, in all countries and continents. The obstacles that stand in the way of the development of mankind's productive forces were overcome for the first time in Russia in 1917, as a result of the victorious Great October Socialist Revolution. The socialist system opened up new opportunities for the development of the productive forces of society, such as were unknown to capitalism and which it was incapable of realizing, and showed in practice that rapid industrial development was possible outside the framework of capitalism, without its aid or guidance.

   The opening up of this new socialist path of industrial development, and the proof given of this vitality in a country hitherto as backward as Russia, was a turning-point in the history of mankind, so far as industrial development was concerned; it also vastly expanded the opportunities available for economic, scientific, technological and cultural development. After the second world war and the formation of the world socialist system the overwhelming majority of mankind obtained for the first time in history a real opportunity to develop industry, science and culture and to free itself of centuries of poverty and insecurity.

6. On the Soviet view of the distribution of shares, see note 5 to Chapter XXI.

7. Doctor of Economic Sciences A. A. Manukyan writes: The authors mention the high costs and other difficulties involved in the exploitation of mineral resources, resulting from the existence of a large number of surface owners.

In this context, mention should be made of the depletion allowances obtained by, for example, the US oil companies, the gross amount of which exceeds actual investments by 10, 20 and more times. These were a means of subsidizing individual surface owners and oil companies in the USA at the expense of the state. In the years 1925–53 this expenditure amounted to 23,397 million dollars (Department of Agriculture, Appropriations for 1959: Hearing before the Sub-Committee of the Committee on Appropriations, House of Representatives, 85th Congress, 2nd Session, 1958, Pt. I, Washington, 1958, pp. 158 ff.). In the socialist countries mineral resources belong to the whole people and are worked in the interests of society.

8. Doctor of Economic Sciences A. A. Manukyan observes: The international oil companies obtain their high rates of profit, not because prospecting in, say, the Middle East is expensive and fraught with risk, but for precisely the opposite reason. The cost of locating an oilfield and obtaining oil from it is dozens, even hundreds of times cheaper in the Middle East than in the United States. According to latest data, in 1947–60 this cost amounted to: 106 cents in the USA, 58 cents in Canada, 23 cents in Venezuela, 10 cents in the Far East, 1 cent in the Middle East. The profits drawn by the big oil concerns are 100, 200 or 300 per cent of their outlays.

9. A. N. Grzhegorzhevsky, Candidate of Economic Sciences, observes that the clearest demonstration of the distorted development of technology under capitalism, especially at the present stage of its general crisis, is its subordination to purposes of destruction. In capitalist countries technology is today developing most rapidly in those branches (atomic energy, cosmic research) concerned with the production of means of destruction. It is those branches that increasingly dominate the trends of technical 'progress' and receive priority in the introduction of new equipment and new production processes. It is no exaggeration to say that the fate of a particular industry, from the point of view of its technical development, is determined in the main by the fact whether or not it obtains military contracts which can ensure mass production in large series. It goes without saying that the development of technology in the branches of the war industry can find partial application in other fields of capitalist production as well. But it is the characteristic feature of such development that the most important technological advances are achieved, as the facts prove, in war industry.

Yet technology is a most important element of productive—and not destructive—forces. This development of the technology of capitalist production does not testify to normal technological progress. See: A. N. Grzhegorzhevsky, 'Contradictions in the Development of Technology at the Present Stage of the General Crisis of Capitalism', in the book: *Usileniye zagnivaniya Kapitalizma v usloviyakh novogo etapa obshchego krizisa* ('Increased Decay of Capitalism in the Conditions of the New Stage of Its General Crisis') (Moscow, 1961), pp. 103–4.

10. *See Chapters XI and XXIV for discussion of total war and the impact of military considerations on industry, technology and even science in all major countries. The spectacular scientific and technical achievements of the USSR as well as the USA in space exploration and long-range guided missiles testify to this impact.*

CHAPTER X

TRANSPORT

THE most spectacular application of scientific knowledge in the twentieth century was in the field of transport. The motor car transformed much of the pattern of living on the earth's surface. The aeroplane lifted man from the earth that had always bound him and carried him swiftly and freely over seas and deserts, jungles, mountain heights and polar ice, indifferent to the barriers which had hemmed him in or blocked his course.

Steam and machines had already brought a revolutionary change in transport in the nineteenth century. Thanks to the railway and the steamship, man had been freed for the first time from the limitations placed upon his mobility by his own powers of locomotion, those of draught animals and the propulsion of the wind. The 500,000 miles of railway lines which extended rapid, cheap, safe and dependable transport to most inhabited regions of the globe had opened up resources and markets and had provided a basis for modern industry. This first revolution in transport had brought new relationships and a great sense of change and expansion. Few dreamed, however, of the revolution in transport which lay ahead.

The second was even more spectacular than the first, for it freed man from the limitations of the earth's surface itself, and it was even more pervasive for it placed in the hands of millions of ordinary individuals the means which gave them almost complete mobility and it broke down the isolation of all except the most remote areas.

In the industrialized countries the influence of the motor car can hardly be exaggerated. What in the early years of the century was an experimental vehicle, of interest to technical experts, racing enthusiasts and a few rich men, became a necessity in the life of millions of families, the cornerstone upon which their manner of living was built. It became a symbol of prestige and status and the basis of a major industry. It led to the enormous extension of roads and provided the basis for a network of services of supply and repair. It introduced a new and serious threat to life in the danger from high-speed vehicles. It loosened the relationships which were based on proximity and thus modified social patterns and altered horizons.

In the less industrialized areas the motor car had not, by mid-century, yet come to play the role of a personal vehicle in the lives of a large proportion of the population or changed whole patterns of life and human relationships. It was important in economic development, in providing public transport, for civil administration and military transport, and as a pleasure vehicle for a small wealthy element. But with the process of economic development the

use of the motor car expanded steadily, presaging a time when it would begin to give mobility to the general population as it had in the most industrialized areas of the western world.

The aeroplane, on the other hand, had perhaps an even more revolutionary impact on underdeveloped than on industrialized regions, although the main volume of air travel and transport was in the latter areas. In the industrialized countries the aeroplane was mainly an accelerator; it speeded up an already fast system of rail and motor transport, making intercontinental and trans-continental travel a matter of hours instead of days or weeks. It speeded up the processes of business, administration and holiday travel but it did not create a radically new situation in civilian life. Its most far-reaching impact in the industrialized areas was in time of war, when it exposed civilian populations to aerial bombardment and transformed whole cities into military objectives.

In the underdeveloped regions of the world, however, the aeroplane was an innovator which brought an end to isolation and opened up regions to which access was most difficult. In one sweep, the people of the high valleys of the Himalayas, of the Amazon jungles, the African bush or the deserts of Central Asia were placed in contact with the world community. However tenuous the link, it was present and real. The Arctic and Antarctic wastes which had offered a grim challenge to explorers could be flown over routinely or made the basis for scientific expeditions supplied by air.

In the middle of the century a third revolution in transport was just beginning as the first vehicles travelled into outer space, opening a new era in which the speeds and distances of air travel were dwarfed to insignificance, and men could think in terms of exploring not merely the earth and its atmosphere but other parts of the solar system.

I. MOTOR TRANSPORT

Efforts to develop self-propelled vehicles which would travel on the road had begun shortly after the invention of the steam engine, but the lumbering devices contrived by various designers in the late eighteenth and early nineteenth centuries long appeared to be merely dangerous nuisances. It was not until 1896 that the British Parliament repealed its law of 1835 requiring a man with a red flag to go in front of any mechanically propelled road vehicle and limiting the latter's speed to four miles per hour.

In the last quarter of the nineteenth century, and especially in the 1890s, much work was carried on in France, Germany, Britain, Austria and the United States to develop practical designs of both vehicle and motor. The horse-drawn carriage provided the starting-point for vehicle design; motor power was furnished by steam, electric batteries and various types of internal-combustion engines. When pneumatic tyres became available in 1889 they provided an indispensable basis for increased speed.

Out of experiments in many places and with many elements of design, the essential features of the automobile emerged around the turn of the century. A few steam models tried for several years to establish steam as a practical alternative to internal combustion, and electrically driven vehicles retained some popularity as long as it was necessary to crank petrol-driven motors by hand. But as petrol cars became more dependable the advantage of not having to wait until steam was generated gave them clear superiority over the steamers, and the self-starter took away the principal advantage from electric propulsion.

Once the petrol-driven, internal-combustion motor car had established itself as the dominant mechanical road vehicle its use expanded with great rapidity, and the industries, services, regulations and know-how related to the operation of such vehicles became part of the economic structure, the legal system and the education of the industrialized segments of the world. By 1955 motor vehicles in the United States were more numerous than homes; there was one motor vehicle for every 2·6 persons in the population. Comparable figures for other countries showed one vehicle per 4·4 persons in New Zealand, one per 9 persons in Denmark, the best supplied of the European countries, one per 70 persons in the USSR, per 92 in Brazil, per 98 in Japan and per 4,975 in China. Five years later cars on British roads had increased to one per 6 inhabitants, and comparable increases were bringing crowded roads to the European continent. Although a dozen or more countries had vigorous automobile industries, the major quantitative development in automobile production came in the United States, where at mid-century more than two-thirds of the world's passenger cars and half of its lorries and buses were being manufactured.

During the second decade of the twentieth century the whole character of the vehicle, as well as its method of manufacture, was changed by the introduction of mass production. Henry Ford in Detroit, USA, conceived the idea of a car designed for the masses, and started in 1909 to produce his Model T by an assembly-line method which made this low-priced car possible. Manufacturers in other countries, such as Citroën in France (1919), soon began to produce for the mass market, and other American manufacturers sought to compete with Ford for the large number of potential American car users. Gradually a pattern developed by which each major producer placed on the market a car which furnished mass sales and other cars for higher income levels. In the United States the low-priced models of the three principal manufacturers provided more than half of total annual passenger car sales in the 1950s.

As distinctive automobile models were developed the motor car became, like its predecessor the horse-drawn carriage, an object of conspicuous consumption. Automobile manufacturers began to emphasize features other than the mechanical excellence of the car in order to encourage the tendency to use the motor car not only as a means of transport but as a means of display.

In the United States the low-priced cars copied the style features of the higher-priced models until the cars on the road became almost equally elaborate and virtually indistinguishable.

Various improvements in design offered the traveller not only increased comfort but, more importantly, increased safety. The metal turret top of the closed car and other features of the metal body made it possible for the car to withstand a very severe impact without collapsing and crushing the occupants. Safety glass, made by laminating sheets of glass with plastic in such a way that the glass would crack but would not break, removed the extreme danger from cutting in case of accident. Hydraulic brakes offered greater security than those which operated mechanically and improved tyres reduced the likelihood that the car would be thrown out of control by a tyre burst. The automobile remained a dangerous vehicle and automobile accidents constituted a major source of death and injury, but these safety features were among the factors which made it possible to place so powerful an instrument in the hands of the public and turn it loose on the public highways without inviting complete disaster. (Pl. 14a, 14b.)

Vehicles designed for military transport included features which were subsequently adapted for civilian use. The jeep, developed in the second world war as a small powerful passenger vehicle capable of traversing very rough terrain, proved immensely useful to farmers, woodsmen, prospectors and in any areas where roads were inadequate and the ordinary automobile, built for the well-surfaced highway, could not travel.

Motor lorries were manufactured in many sizes and types for a wide variety of cargo transport. At first lorries were used chiefly to carry relatively small loads short distances while railways hauled the long-distance heavy or bulky loads. In time, however, large transport vehicles began to compete with the railways as carriers of many types of freight. Huge trailers, detachable from the motor vehicle which drew them, could be loaded at a factory or warehouse and then picked up for hauling to a near or distant destination.

The production of motor vehicles and the building of roads, both of which steadily improved in quality and increased in scope, made motor transport a major factor in economic life by the middle of the twentieth century. Road transport vehicles were carrying a growing proportion of the world's freight, including the vast bulk of all short-haul loads. Motor transport had also become the chief means of passenger travel. Even excluding private vehicles, buses rather than trains were providing the means of inter-urban travel for the majority of passengers in more and more areas.

The enormous volume of motor travel required a great range of facilities. First and foremost were the highways. The roads surfaced with sand or gravel which had served for the traffic of horse-drawn vehicles were soon found to be entirely inadequate for motor transport. The car or lorry whipped up a cloud of dust, loosened and wore the surface and broke down the road-bed with its weight. The unsuitability of existing roads for motor travel was

dramatized in 1903 when so many of the drivers in the Grand Prix automobile race from Paris to Madrid were blinded by dust and crashed that the race was called off in mid-course to save the lives of the surviving drivers.

The basic construction for road-building developed by Macadam in Britain at the end of the eighteenth century continued to be used, but asphalt or other binding material provided a solid surface. For major highways carrying heavy high-speed traffic, slabs of reinforced concrete were laid over well-drained road-beds whose depth and material were adjusted to local conditions of soil, moisture or frost. For safety and to permit high-speed travel, motor roads were widened, straightened and, on major routes, divided by a central barrier to prevent head-on collisions.

As long-distance motor travel increased, efforts were made to separate through traffic from local by providing special through motorways. Italy took the lead in the 1920s with the construction of *autostrade*, which could be entered only at specific points and from which pedestrians and slow-moving traffic were excluded. In the 1930s Germany constructed a series of *autobahnen* for military purposes, and the USA began to develop an elaborate network of limited-access high-speed highways, the first of which, the Pennsylvania Turnpike, was opened to traffic in 1940. These fast throughways permitted extremely rapid automobile travel from city to city. In 1957 there were nearly 4,000 miles of such motorways in West and East Germany and formerly German Poland, about 600 miles in the rest of Europe, mainly Italy, and some 2,500 miles in the United States. (Pl. 11b.)

Motor travel depended upon the ready availability of fuel, since each vehicle carried only a limited supply. The oil resources on which the whole system of motor travel and transport rested were localized in a few areas, at first the USA and northern South America, Rumania and southern Russia, then the Persian Gulf, the Indonesian archipelago and the Arabian peninsula. The pipelines, tanker fleets and tank cars which brought petrol great distances to points of use were the lifelines of the motor age. In areas where traffic was heavy, retail petrol-supply points were necessary at frequent intervals along the roads and the petrol service station became a ubiquitous institution.

The motorist was almost equally dependent on being able to find services of repair. When the motor car was a new instrument, driven only by people with special knowledge and interest in it as a mechanism, drivers carried their own tool-kits and some spare parts, and were equipped to make repairs to tyres, motor, or mechanical parts if these should break down on the road. As the motor car itself became much more complex and was driven by millions of men and women who had no specialized mechanical knowledge, motorists ceased to be able to make their own repairs and counted upon finding a mechanic not too far away if anything went wrong. Many service stations combined repair with petrol-supply services and kept on hand the spare parts most usually needed; and associations of motorists provided road patrols or emergency repair crews constantly on call.

Motor travel brought an immense expansion in overnight accommodation and a change in its form to suit the mode of travel. Hotels were urban phenomena. Especially after the railway replaced stage-coach travel and rendered unnecessary the roadside hostelries for man and beast, travellers found overnight accommodation in the towns, frequently near a railway station. But motorists did not want to struggle through congested traffic to the centre of a town where there was no place in which to park their car for the night.

At first private citizens who lived on main roads offered tourist accommodation in their spare rooms; then they built small one-room cabins with space at the side for the car. It was a small step to convert these groups of cabins into a more elaborate motor hotel or motel, and then to design motels equipped with many of the features of urban hotels. By mid-century the highways approaching many cities in the United States and Canada, as well as those in tourist and holiday areas, were lined with such motels and the pattern was spreading to other countries. For motorists who travelled by caravan or carried camping equipment, municipalities, public parks and private landowners offered caravan and camp sites equipped with water and sanitary facilities.

Motor traffic urgently required regulation, and all countries placed legal restrictions on the use of the roads. The most basic regulation, specifying the side of the road on which a vehicle shall drive, was first enacted in Britain by the Highway Act of 1835 which prescribed left-hand driving for carriages and animals, replacing the common law principle that permitted driving anywhere on a public highway. Britain was also one of the first countries to establish a practical speed limit—14 miles an hour in 1896, raised to 20 miles per hour in 1903. In 1930 Parliament abolished all speed limit for private cars and motor cycles, but the high rate of fatalities which followed led to the re-establishment four years later of a limit, 30 miles per hour in built-up areas, though the speed of private vehicles remained unrestricted on the open road. Continental European countries also imposed speed limits in built-up areas. Traffic regulation in the United States remained the responsibility of states and municipalities, which established different speed limits and other regulations for their highways and streets.

Motor vehicle regulations included the licensing of those who were permitted to drive on the highway, and generally required a certain age and demonstrated ability to handle the vehicle before such licence would be granted. Drivers were required to carry their licences at all times, and were subject to fine, arrest or revocation of licence if found driving without a permit or in an unsafe manner.

It was essential, however, that drivers passing from one jurisdiction to another should know what was expected of them. Model vehicle and traffic regulations were formulated and adopted by many jurisdictions, and reciprocity was arranged in respect to licensing and other requirements. The League of Nations developed a motor traffic convention in 1926 providing for inter-

national driving licences and uniform danger signals. This convention was put into effect generally in European countries and some others. Interrelated American motor traffic conventions were developed for the Western hemisphere by the Pan American Union in 1930 and 1943. The United Nations carried forward the League of Nations' work and developed uniform international symbols for road signs so that safety would not depend on the driver's knowledge of the language of the country.

Yet in spite of the elaborate systems of traffic regulation, the toll of motor accidents mounted steadily as more and more vehicles, with more and more capacity for speed, crowded the streets and highways. More than 35,000 people perished annually from motor accidents in the United States in the 1950s. In Great Britain during the second world war the number of road deaths was more than two-thirds as great as the fatalities from air raids, in spite of the fact that motor travel was severely limited by petrol rationing.

The menace to life and limb was not the only disadvantage brought by motor traffic, along with its many advantages. Congestion of roads leading into cities and of city streets grew worse with each passing year, often virtually nullifying the advantage of speedy motor travel by reducing traffic to a crawl across bridges or along main thoroughfares. To this was added the problem of parking. Much street space which would otherwise have been available for travel was occupied by parked vehicles, but still the driver often searched vainly for a place to leave his car. Fumes from the exhaust of thousands of vehicles became a menace to health; studies of factors producing smog, of the possible causes of lung cancer, and of the aetiology of other diseases sought to assess the impact of exhaust fumes on the public. Noise, too, contributed to the wear and tear of city living. In an effort to halt the constant grating of motor horns on the nerves of city dwellers, major cities forbade the use of the horn within the city limits, but the traffic roar continued.

The cultural impact of the motor car on virtually all aspects of life was tremendous in the countries where its use became general. The impact was most conspicuous in the United States, but as the number of motor cars in Europe mounted by leaps and bounds in the prosperous years which followed the recovery from the second world war, European life was increasingly affected in the same ways. The automobile was part of the equipment for living of over 70 per cent of the families in the United States by 1955; one family in ten owned two cars or more.

The motor car furnished the link between the place of living and the place of work; it provided the means for social contact, so that individuals were decreasingly dependent for their social life on those who lived in their neighbourhood, or even in their town. Motor travel became a favourite means of recreation and the motor car gave access to other sources of recreation also, such as ball games, racecourses, swimming and boating resorts. The automobile could affect patterns of courtship; it could promote some types of family activity and impair others; it might become a bone of contention

between members of the family who might wish it for alternative uses. At best it occupied a very large place in the family budget and, when used as an expression of social status as well as a means of transport, it often strained the budget severely.

Not the least of the automobile's influences was the psychological impact of its use. Behind the wheel of a car every man was a master, in command of tremendous horsepower, able to inflict enormous damage, having to yield to no one so long as he respected the traffic rules—a king indeed. Small wonder that the adolescent could hardly wait until he reached the legal age at which he might enjoy this sense of manhood, and that he was sometimes tempted to abuse it.

The impact of the motor car on the city itself was not less than on its individuals. Older cities had tended toward central congestion as activities crowded into sites which were as accessible as possible to rail or ship terminals, or to other centrally located activities within the city. Only the high cost of centrally located land and the sheer fact of physical congestion limited the number and proportion of the city's business, industry, and population which responded to these centripetal tendencies.

The motor car largely reversed the process. On the one hand it made access to the suburbs easy and interconnections between one suburb and another possible. On the other it reduced the centre of the city to an impossible snarl.

Shops which had sought central sites to serve the greatest number of customers began to establish branches on the outskirts; suburban shopping centres with ample parking space came to serve those who lived in the outer parts of the city, as well as suburban residents. Factories, too, were located in open spaces where land was cheaper, factory buildings could be designed with less congestion, and where employees could have acres of land on which to park their cars. And always the suburbs grew and grew, spreading out in what came to be known as the urban sprawl, the characteristic living pattern of the motor age.

The motor car contributed, too, to a rootless manner of living. Caravan homes—though not numerous in proportion to those who lived in houses—introduced an element of impermanency into communities where they were located and developed a population of wanderers with no local ties. Migration in search of jobs, the constant need and opportunity to make new social contacts, the breakdown of every type of isolation—these were all parts of the restless, on-the-move pattern which the motor car had brought to mid-twentieth-century life.

II. AIR TRANSPORT

The aeroplane added a new dimension to men's lives. The limitless future of the plane was immediately presaged when the Wright brothers, on December

17, 1903, made their famous flight at Kitty Hawk, North Carolina, USA, to demonstrate the possibility of powered flight by a heavier-than-air vehicle. Once the possibility had been established, the rest was simply a matter of progressive refinement. (Pl. 15a.)

Constantly increased knowledge of aerodynamics provided the basis for improvement in aircraft design. The Wrights' two flimsy wings supported by struts were replaced by a single wing shaped to get the maximum lift from the air flow. In turn, what came to be a conventional design of wing, fuselage and tail gave way in the fast military planes to flying wings of various shapes.

The internal-combustion petrol engine used for power was greatly enlarged, its power and speed enormously increased, and its fuel more and more highly

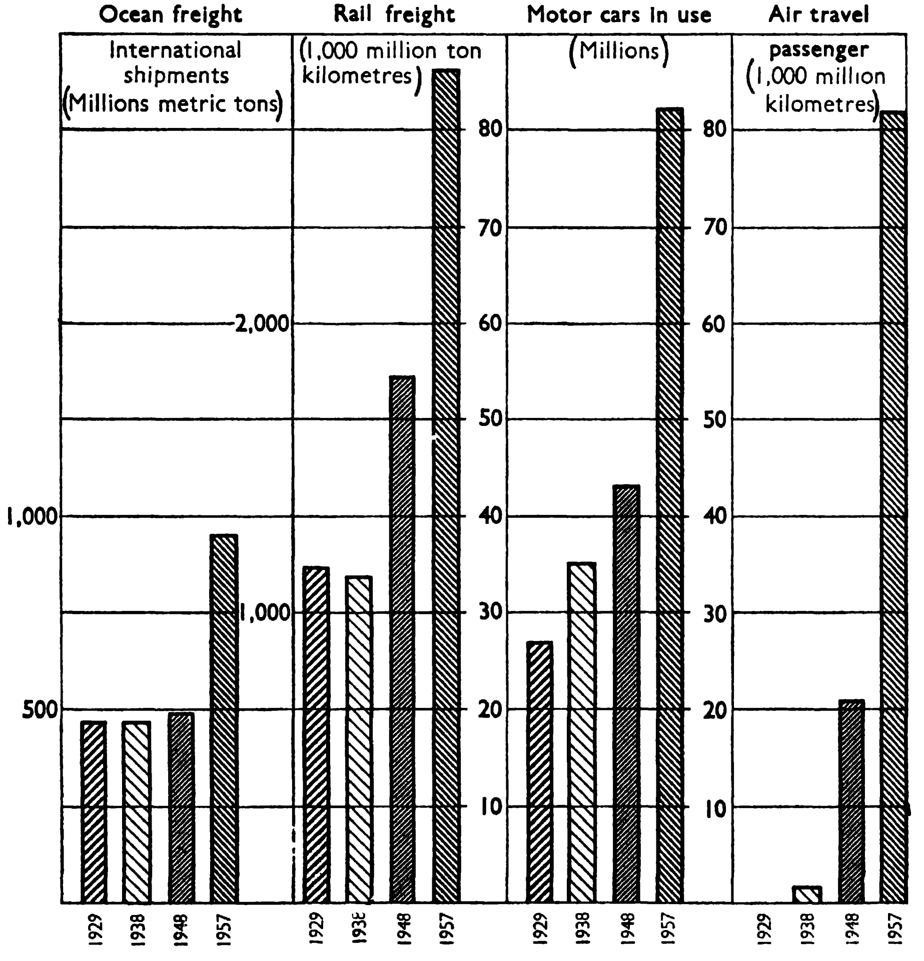


CHART XIII. Transport and Travel—Sea, Rail, Motor, Air, 1929, 1938, 1948, 1957.
Source: *U.N. Statistical Yearbook*, 1960.

refined. During the second world war, the jet principle of propulsion by explosive thrust instead of by whirling propeller was introduced in fighter planes, and it spread in the decade after the war to most types of military aircraft and then to commercial planes, first in combination with the 'prop' or propeller, and finally in designs first put into use by the British and the Russians, in wholly jet-powered commercial planes. (Pl. 15b.)

A constant succession of new light metals and metal alloys, immensely strong and resistant to very great heat, made it possible to build larger and larger planes and motors operating at higher and higher speeds. Means of pressurizing the passenger cabin were devised when it became practicable to fly at great altitudes. Control devices were perfected to make the plane manageable under every sort of condition—de-icers to prevent the formation of ice on the wings in passing through cold and moist air, an all-important protection against additional weight and unmanageability, wing flaps to give increased lift at slower landing speeds, reversed propellers to brake the plane on landing, automatic course-following controls, and finally radar to give the pilot eyes to see through fog and dark.

All of these developments combined to enable planes to beat their own records for speed and distance continually, and to carry larger loads more safely. For a time it appeared that the speed of sound constituted a barrier to further acceleration, but once the sound barrier was broken in 1947 there seemed no bar to greater and greater speeds. The record in January 1957 stood for the moment at 1,182 miles per hour, nearly twice the speed of sound. At almost every step military aviation paced civilian in technical developments, especially in speed and power, but in time the military advances were adapted for civilian use.

The following table indicates dramatically the rapidity with which speed and distance were increased.

	Time required to cross the US *from New York to the west coast*	*Record non-stop flights (miles)*
1908	—	77·5
1911	—	460
1923	26 hr.	2,516
1933	10 hr. 5 min.	5,308
1946	7 hr. 28 min.	11,236
1955	3 hr. 45 min.	—

Prior to the first world war the aeroplane was still an experimental instrument. An airman was a daring individual. His principal activity, and often his source of income, was to manœuvre his plane for the benefit of spectators attending a fair or flight exhibition. In the first world war military aircraft were used for reconnaissance, accompanied by fighter escorts to protect their operations; only toward the close of the war were a few bombers put in the air.

Commercial aviation was the product of the inter-war years. Contrary to

the expectation of many people that the aeroplane would follow the course of the motor car, there was only a limited development of private flying and the private ownership of small planes. Private plane owners included farmers overseeing large ranches in the western United States or Australia, a few groups of fishermen who used small privately operated planes to spot schools of fish, an increasing number of large corporations which used company planes to transport their executives, a few flying enthusiasts or some rich men who used private planes to reach hunting or fishing camps. For the most part civilian flying remained on a commercial basis, and grew enormously in volume in all parts of the world.

By the middle of the century air transport had become a principal means of long-distance passenger travel. In 1955 it accounted for more than a third of all passenger traffic in the United States, and in 1958 the number of transatlantic air travellers exceeded those crossing by surface vessel. Except for mails and some perishable cargo, planes were not yet carrying an important proportion of the world's freight.

Planes were however used for many civilian purposes other than passenger and cargo transport. They patrolled forest areas on the look-out for forest fires, prospected for minerals, conducted aerial surveys, photographed and mapped terrain, sprayed or dusted farmlands with insecticides, flew relief supplies to people marooned by flood or snow and brought medical assistance to out-of-the-way places. In the USSR they were used to carry newspaper matrices so that the same paper could appear simultaneously in national and provincial capitals. In countries such as Iran or Arabia, where populations had been isolated by difficult or impassable terrain, planes permitted rulers to maintain contact with their subjects in far-away corners of their realms and brought them a sense of national belonging. The helicopter, which required no landing field, could take off vertically and could hover close to the ground, was particularly well adapted for rescue work or to deposit forest-fire fighters behind a blazing area and then lift them safely out, as well as for mineral prospecting and for hoisting operations on construction jobs in inaccessible sites.

The importance of the aeroplane in areas of difficult terrain, great distances and sparse population was evidenced by the particularly rapid and extensive development of civil aviation in Latin America, Canada, Australia and the USSR. The oldest of the Latin American airlines, Avianca of Colombia, originally established in 1919, carried more cargo in the 1950s than any other scheduled airline in the world. In a country such as Colombia, which is broken up by mountain ranges into self-contained valleys, the plane provided a basis for national integration and development. Brazil, with its immense undeveloped territory, had some twenty airlines in operation in the 1950s flying more than 100,000 miles of route. All of the principal Latin American countries established one or more airlines and by the 1950s had ceased to depend on the foreign aid, at first German and French and later North American, with which their civil aviation had been started.

Canada started after the first world war to use aircraft for surveying and patrolling its vast forest area and maintaining communication with remote settlements. By the time that a major company, Trans-Canada Airways, was formed in 1937 to fly the main domestic routes and provide international service, Canada had been covered by a network of many small airlines spanning great distances and connecting up its sparsely settled territories. Australia, from 1921 on, depended more and more on aviation to link the cities and settled areas which ringed its vast interior desert and to reach the lonely stations of ranchers and sheep farmers in the interior. For the USSR air service offered access to its central Asian regions and brought Siberia, once a symbol of inaccessibility and distance, within reach of the capital; airlines in the Asian part of the USSR were first organized in 1924 and regular service between Moscow and eastern Siberia was established in 1930.

Many of the world's international air routes were established by the British, French, Dutch and Belgians in the 1920s and 1930s to serve their overseas empires. British Imperial Airways Ltd., chartered in 1924 and subsidized by the British government, was charged with special responsibility for developing routes throughout the Commonwealth. In the decade 1927–37 it extended its routes via Cairo and Baghdad to all parts of India, Burma, Malaya, Australia and Hong Kong, and it surveyed the routes through Africa which it began to fly after the interruption of the war. By 1931 the French were flying to Indo-China and to several parts of the French African empire. The KLM, supported from its start in 1919 largely by the Dutch government, extended its service from Europe first to Indonesia in 1924 and then to the Dutch West Indies in 1934. Belgium's Sabena airline included service to the Belgian Congo. Germany, with no overseas colonies after the first world war, concentrated on service to South America, first by Zeppelin and then also by plane, and helped to develop civil aviation in several Latin American countries.

The United States developed civil aviation more slowly than many other countries, in part because it had few inaccessible areas or overseas dominions. The principal early development in the US was for the flying of the mails. Once American commercial aviation began to boom, after Charles Lindbergh's dramatic solo flight from New York to Paris in 1927, it attracted travellers at such a rate that US airlines in 1955 were flying more passenger miles than all the rest of the world's airlines, exclusive of the USSR and China, combined. The first passenger services across the north Atlantic (1939) and the Pacific (1935) were inaugurated by the Pan American Airways.

The first commercial airlines were struggling private ventures, but soon the recognition of their national importance led to their being subsidized by governments, either directly or by such devices as a generous contract for carrying the mails. By the years after the second world war, nearly every country except the smallest had its airline, not alone for internal travel but for international travel and transport as well. A trend toward international air unions was inaugurated with the formation in 1950 of the Scandinavian Air-

lines System which brought into a single air-traffic organization the airlines of Sweden, Norway and the oldest of all national airlines, the Danish Air Lines established in 1918.

Concern for public safety in view of the great hazards involved in flying, together with the necessity for adequately constructed and carefully regulated airfields and the international aspects of air travel, led governments to establish regulatory bodies, and to develop rigorous national and international codes of both safety and conduct.

The first step in international air traffic control was a convention adopted in Paris in 1919, providing that private aircraft should be permitted to fly over the territories of participating states, but not extending this privilege to commercial air service. In 1944 representatives of fifty-four nations met in Chicago, USA, to seek agreement on commercial air rights and on international air traffic. Owing to a basic conflict over how far international aviation should be competitive and how far it should be regulated so as to assure a proportion of the traffic to the carriers of different countries, no general agreement was reached and the right of foreign passenger planes to fly into any territory remained subject to agreement between the two countries involved in each case.

The Chicago meeting did however produce a convention on international civil aviation covering technical regulations, standards and procedures, which was signed by virtually all companies providing international air passenger service outside the communist zone. The International Civil Aviation Organization (ICAO) with headquarters in Montreal, Canada, which was set up as a result of the Chicago conference, became a specialized agency of the United Nations. The sanitary aspects of air travel and airport conditions, of extreme importance in view of the danger of the spread of disease by air, was brought under international control by a convention signed at The Hague in 1933. After 1946 the World Health Organization took over responsibilities in this area and issued comprehensive international sanitary regulations for airports to safeguard world health.

By the mid-1950s air travel throughout the world generally conformed to common standards and procedures, and only a few of the detailed amenities associated with the flight were likely to remind the passenger where he was and by what airline he happened to be travelling.

With all these developments commercial flights became safer and people generally overcame the fear which had made them reluctant to use this mode of transport. What was at first a luxury form of travel gradually became an everyday means of reaching a destination. The volume of air passenger miles mounted steadily.

Although the record of air safety was impressive, the increasing size of the planes made disasters when they occurred more costly in lives. The collision of two large airliners over the western American desert in 1956 sent 128 people to their death. Each crash was a spectacular reminder that the air was never wholly safe.

Great precautions were essential around the principal airfields where planes landed and took off minutes apart and where a delay in schedule because of bad weather or mechanical difficulty could mean additional planes circling the field waiting for a signal to descend. The highly skilled traffic directors in the control towers, equipped with radar to watch the approaching planes as well as radios to hear the pilots' reports and give instructions, were hard pressed to keep track of the complex traffic pattern. Military aircraft travelling at supersonic speeds added to the hazards in the sky. By the late 1950s it was becoming apparent that in order to avoid disaster in the air something faster and surer than human communication and observation would have to be employed to control air traffic if the trend toward more and faster planes were to continue, and electronic controls were beginning to be used.

III. PIPELINES

The expansion of motor and air travel, together with other uses of the internal-combustion engine, required the transport of an immense amount of liquid fuel. Increasingly, this was carried by pipelines through which oil and petrol were pumped from wells or refineries to distant markets or ports. As liquid fuels gained in both absolute and relative importance, pipelines became a significant part of the world's transport system.

The first pipeline through which petroleum could be pumped was laid in Pennsylvania, USA, in 1865, six years after oil production began. As the production of oil in the United States expanded, many thousands of miles of pipelines were constructed from centres of production to distant consumption areas. In the 1950s some 80 per cent of the world's oil pipeline capacity was still in the United States, but pipelines were built to carry at least a substantial proportion of the output of the fields opened up in other areas—in Russia where pipeline construction, begun in 1917, was extensive, in the Middle East where oil from the region of the Persian Gulf was pumped to the eastern Mediterranean, in South America and south-east Asia where it was piped to the ports, and in North Africa to carry oil from the Sahara. In the 1950s lines were being built within Europe, from northern and southern European ports, to distribute the oil on which the European economy was coming increasingly to depend.

Pipelines provided the sole means of transport for natural gas which was carried long distances, mainly in the United States and Canada but also in the USSR, France and Italy. They were even beginning to be used for solid products which could be transported in powdered form, such as coal, limestone and some dry building materials.

IV. RAILWAYS

Although the revolution in transport in the twentieth century was brought by the automobile and the aeroplane, railways continued to be the largest carriers of freight and the most indispensable links in the industrial system.

Their military importance for troop transport remained great, because of the large numbers of passengers that could be carried in one load. Their relative importance in the total transport picture, however, declined.

Passengers travelled by motor car or bus for short distances and by plane for long ones. Railways found their passenger travel dropping off; they reduced their passenger service in order not to lose money running half-empty trains, but they thereby discouraged passenger travel further by the absence of trains at convenient times; on the less travelled routes, railways abandoned passenger service altogether.

For freight, also, motor transport competed effectively with rail for short hauls, especially since a motor lorry could be loaded at the point of shipment without having to be reloaded at the freight terminal, and could deliver direct to its destination. Goods shipped in small lots required less handling when sent by lorry than when they had to be packed into a large goods wagon with many other shipments. Savings in handling often meant greater speed from shipping point to destination and less damage to cargo, and thus gave the lorry an advantage over the train in the shipping of perishables and breakables. High-value freight which was light, especially that which was also perishable, could be transported advantageously by air. At the other end of the scale, water transport had always offered serious competition to rail for bulky non-perishable items such as iron ore or coal, which did not need to be transported rapidly.

Although railways remained the backbone of the industrial transport system their position deteriorated steadily and they were at considerable difficulty to keep solvent. They resorted to a number of measures to improve their operation as new technical developments permitted, though their basic technical features remained unchanged. More powerful locomotives, specially designed carriages and more heavily ballasted road-beds permitted greater speeds on streamlined trains. Lines were electrified, first in the vicinity of major cities, then more generally. Bit by bit, the oil-burning diesel engine replaced the steam locomotive. (Pl. 12a, 12b.)

In some regions the extension of the railway during the twentieth century was a means of opening new territory and of creating important transport links. The trans-Siberian railway completed in 1917 joined the centres of European Russia with its Pacific port. The Berlin-to-Baghdad railway, projected by Germany in the years before the first world war, was finally completed in 1940. The British vision of a through route from Cairo to Cape Town still lacked many links at mid-century, although there had been considerable railway construction in connection with the mine operations of the Rhodesias, the Congo and South Africa. Among the greatest additions to the world's railway mileage in the first half of the twentieth century was the network of lines which opened up Manchuria. Major railway developments in China continued under the Chinese People's Republic with the construction of a route westward into Sinkiang.

Railways thus continued to afford a means of opening new areas and providing an essential element in the industrial base for the underdeveloped areas in the twentieth century as they had done for the industrially advanced countries in the nineteenth century. Even in these regions, however, the aeroplane often preceded the locomotive and roads were as likely to be the penetrators as were railway lines. In some non-industrial areas which passed from animal transport directly to air and motor travel, it appeared unlikely that railways would ever be constructed.

A major aspect of the problem of railways in the twentieth century was that of the rates to be charged. Both where railways were government ventures and where they were private companies operating under government regulation as in the USA, and in Britain until nationalization in 1947, the rate structure was based upon a balanced load—i.e. a balance between long and short haul, between low-value heavy freight and high-value light shipments, and between small and large consignments. Under this system some items that were more profitable to carry balanced the less profitable, and bulky goods were transported at a cost which was not prohibitive.

Commercial road vehicles, initially without regulation, were under no compulsion to carry a balanced load. They could skim the cream, hauling the profitable items and leaving the railways to haul the less profitable ones. The railways, in turn, were not in a position to raise their rates on the remaining items in order to make their operation profitable, both because of regulation and because of the economic impact of such a move. This dilemma was at the heart of the rate-making difficulties confronting all railways as motor transport grew.

This problem presented itself in all industrial countries. Everywhere policy had to balance two considerations and to work out an effective compromise in the national interest. All governments recognized the importance of keeping the railways in vigorous operation, if for no other reason than that they were an indispensable part of the military structure, a strong reserve which could not be allowed to deteriorate. On the other hand the new and flexible motor transport had obvious advantages, which in the interest of the national economy should be encouraged and utilized. In the 1930s countries began to regulate their motor transport as they had their railways or they incorporated all rail, road and other transport into one single state-regulated system. Socialist economies sought a balanced use and development of their several means of transport through the application of their economic plans.

But railways were far from becoming obsolete in the course of the first half of the century even though motor, pipeline and air transport largely supplanted them for short hauls and in the carrying of passengers, small shipments, perishables and liquid fuels. They continued to be the most effective means of mass transport for large consignments and they remained a main form of transport, especially in countries with extensive continental territory. In 1955 the railways of the USSR carried more than four-fifths of the total freight trans-

ported. Even in the United States, with the world's most highly developed motor transport and road system, nearly half of all freight still travelled by rail.

V. WATER TRANSPORT

Ocean transport remained the chief means of overseas shipment, and ocean tonnage kept pace with the expansion of production throughout the world. Its vital importance to the life of all industrial countries was amply manifested during the two world wars, when the sinking of merchant shipping became one of the most crucial of military operations and the one on which much of the outcome depended. Although a steadily growing proportion of travellers crossed the oceans by air rather than by surface vessel, the total increase in international travel kept the number of ocean travellers growing, and freight continued to be sent almost wholly by surface, since only the most valuable and perishable cargo could bear the cost of shipment by air.

Inland waterways, which in many places had been the major means of moving heavy loads from one place to another before the advent of the railway, declined in importance with the growth of rail and motor transport. But the construction of canals as parts of comprehensive river development schemes gave inland water transport new prominence. Such canals formed important parts of the industrial development programmes of countries with large river systems, notably in the USSR, whose network of inland waterways was the longest in the world, in India and especially in the Chinese People's Republic. Improvement of port facilities increased the efficiency of the older inland waterways, notably in Europe and North America, and helped them to maintain their relative position among alternative means of transport.

The principal technical developments in water transport, after the original introduction of the steam vessel, had come in the late nineteenth century, when the compound steam engine and the steam turbine permitted a great increase in the speed, size and economy of ocean vessels. During the twentieth century, the substitution of oil for coal to produce steam and the introduction of the diesel engine increased the sailing range and economy of the vessels and freed space in the hull formerly occupied by the bulkier fuel, thus making it possible for a given vessel to carry more cargo. By the opening of the second world war virtually all naval vessels, ocean liners and most freighters either used oil as fuel for steam engines or were diesel-operated. Motor and diesel-electric vessels were widely used on inland waterways and high-speed vessels which employed the hydroplane principle to lift them partially out of the water were beginning to be introduced. (Pl. 13a, 13b, 13c.)

Among naval vessels the submarine represented the newest development of the period. First extensively developed in its modern form by the Germans as a means by which a largely land-locked power could challenge the supremacy of the British on the seas, the underwater vessel became part of the

fleets of all naval powers in the period between the two wars. Through the years, the submarine's range, speed, ability to submerge rapidly and other aspects of manœuvrability were greatly enhanced. The submarine was the first type of vessel in which atomic fuel was successfully employed as a source of power. Among surface naval vessels the aircraft carrier represented the chief innovation. The battleship, once the queen of the fleet, proved vulnerable to submarine and air attack and by the end of the second world war had become largely obsolete.

For general civilian use the petrol or diesel engine in small craft played somewhat the same role as the internal-combustion engine in the motor car. The small marine engine transformed all types of fishing craft, from the one-man boat which made the rounds of fish or lobster traps to the trawlers which dragged the bottom with great nets. Pleasure boating took on many of the features of pleasure driving. With lightweight outboard motors which could be attached to small open boats, or with built-in engines in motor boats of all sizes, thousands of people went fishing, travelled the bays and shores and rivers, and enjoyed the sea air. When the British troops were driven to the beaches of Dunkirk after the fall of France in 1940, it was the little boats which poured out of British rivers and bays that effected their rescue and averted a complete disaster.

VI. RAPID TRANSIT

The enormous cities so characteristic of the twentieth century depended not only on transport from without but rapid transit within, for hundreds of thousands of people to travel to and from work or from place to place on business or pleasure.

At the turn of the century traffic within western cities was being carried by electric tramways, running on rails through the city streets and generally supplied with power by an overhead cable. Many of the largest cities—London, Paris, New York, Boston, Chicago—already recognized that surface tramways could provide neither the volume of transport nor the speed required by the growing city, and had started to construct elevated tracks and underground railways. The first section of the London Underground was opened in 1863, the Budapest underground railway, first of its kind on the European continent, was opened in 1896, that of Glasgow in 1895 and the Paris Metro and Boston subway in 1898. Chicago put a high-speed elevated electric railway into operation in 1895. New York, which came to exceed all other cities in the length of its underground and elevated rapid-transit system and the volume of passengers carried, ran its first underground train in 1904. As each major city grew in size, it constructed or extended its rapid-transit system. The construction of the Moscow underground in the 1920s called forth much national effort and enthusiasm, not only for its utilitarian purpose but as a symbol of the fact that Moscow had become a great modern city. The volume of traffic

told the story of how the life of these cities was dependent on their rapid-transit services. The underground railway systems of New York, Paris, London and Moscow in the 1950s each carried average loads of two to five million passengers a day. (Pl. 12c.)

While electrically operated underground systems were being extended and carrying ever greater loads, surface street railways declined. Tracks in the middle of city streets interfered with other traffic; their extension to new areas as the city expanded was costly. From the 1920s on, the motor bus offered a much more flexible alternative. Paris abandoned its tramways in 1937; London trams were gradually replaced until they had disappeared by 1952.

With the steady increase in individual car ownership, private transport in the 1950s competed seriously with public surface travel, especially in the United States where private car operation was most general. In some cities, ironically, the very increase in mobility which the motor car brought to countless families and individuals reduced the mobility of others by making public transport unprofitable and leading to high costs and deterioration of service. Even where bus service was maintained as part of a unified municipal or state transport system operated in the public interest, traffic congestion resulting from the presence of private cars lowered the efficiency of all public surface transport.

VII. THE BICYCLE

Though the aeroplane brought the most dramatic change in the spatial relations among men, and motor transport entered most widely into the economic patterns and the personal lives of the people of the industrial countries, the humble bicycle remained an essential mode of transport in Europe and Asia up to the middle of the century. Easily tripling on level ground the speed at which a person could walk, while reducing the effort required, the bicycle enlarged the individual's range and gave him a flexible means of getting to work or to a shop, delivering a message, policing an area, visiting a friend or reaching a fishing stream. European workmen by the hundreds of thousands bicycled to work; farmers in many areas used bicycles to reach a shop, a distant field, a neighbour's home or a nearby town; families used these vehicles for Sunday outings, sometimes on lanes especially provided alongside the motor vehicle roadway. At mid-century the bicycle was still the most numerous class of vehicle on the roads of Britain, France, Germany, Holland, Italy, Belgium and Denmark.

In Asian countries the bicycle represented the first widespread application of mechanical principles to transport in areas where human beings supplied draught power. The bicycle cab or pedicab replaced the man-drawn rickshaw as the principal means of public transport in such cities as Djakarta, Singapore, Bangkok, Rangoon and Taipeh, and bicycles by the millions provided

the principal alternative to foot-travel in India; bicycle manufacture rated as one of the key industries under that country's economic development plan.

With the development of the petrol motor, bicycles also were motorized. Heavy motor cycles, sometimes equipped with sidecars and having the essential qualities of small automobiles, were used for police-work and as a sports vehicle or means of getting to work. In the period after the second world war small auxiliary motors began to be used extensively on ordinary bicycles to increase their speed and ease of operation without essentially altering their character as simple, light, easily handled, easily stored, personal means of getting about.

By mid-century the bicycle had been virtually driven off the dangerous, high-speed, automobile-filled highways and streets of the United States and Canada and was used mainly for children's recreation. But it was still indispensable to many people in Europe, as the Italian film *Bicycle Thief* (1947) poignantly recorded, and it was the first mechanical possession and the first step in acquiring the mobility so characteristic of the modern age for people emerging from poverty or isolation in non-industrialized parts of the world.

VIII. THE SPACE AGE

By the late 1950s the 'air age' was beginning to yield to the 'space age'.

There had long been speculation as to whether life could and did exist elsewhere within the earth's solar system, or in the universe, with the planet Mars the principal candidate for such a habitat. A trip to the moon was a favourite fantasy; Jules Verne wrote *From the Earth to the Moon* in 1885 and one of the earliest motion pictures was Mélies' *A Trip to the Moon*. But when science fiction writers began to produce stories of space travel, and a few serious scientists began to insist that the concept was not impossible, the space age began to dawn. By 1957 it had become a reality.

As part of the Universal Geophysical Year 1957–58, the USA and the USSR both announced the intention to place man-made moons in orbit around the earth for scientific observation. That such a proposal could be made was the measure of transport advance. The proposal to place an earth satellite in orbit rested on the application of the rocket techniques developed in connection with the jet propulsion used in flight and by the German V2 rockets in the second world war. A rocket system which would travel the necessary distance to escape the earth's gravitational pull was an extension of the system which was filling the air with familiar jet-planes.

When the Russians placed the first *sputnik* in orbit on October 4, 1957, the sense that man had taken one of the biggest steps in human history electrified the world. When a few weeks later another *sputnik* travelled aloft with a live dog on board, the question became not whether but when man would be next.

In the following years a succession of United States and Soviet satellites and rockets, launched into space and returned to earth with experimental animals and scientific equipment or sending back radio and television pictures, provided much data on temperature, radioactivity and other conditions, and prepared the way for astronauts and cosmonauts to travel into space. (Pl. 3b.)

CHAPTER XI

COMMUNICATIONS

IN 1955 a person almost anywhere on the globe could send a telegram or speak by telephone to practically any other place, to ships at sea, trains or automobiles on land and planes in the air. He could hear messages broadcast from the Arctic or Antarctic regions or the Antipodes. Most people in North America, many in Europe, the USSR or Japan, and a rapidly growing number elsewhere, could view on television events hundreds and even thousands of miles away. The daily press offered stories and pictures received by teletype and telephoto. If a citizen visited his local airport he could see on the radar screen planes hidden by cloud or dark. Wherever these communication facilities existed, space and time had virtually been eliminated.

I. DEVELOPMENT OF MEDIA OF COMMUNICATION

These developments were foreshadowed before the end of the nineteenth century, for most of the basic elements that entered into the twentieth-century systems of communication had been discovered or tested experimentally and some were in extensive use. The telegraph, already in use in 1900 for half a century, linked major centres, not only over land where telegraph wires followed most rail routes and often extended beyond them, but by submarine cables across the Atlantic and between North and South America. The telephone, invented in 1876 by Alexander Graham Bell, had been generally introduced in the principal cities of Europe and North America, and in rural areas of Germany where it connected more than 800 rural post offices; by 1900 there were already 1,355,900 telephone sets installed in the United States. Marconi had received a patent for wireless telegraphy in 1896 and succeeded in sending a wireless signal across the English Channel in 1899 and from England to Newfoundland in 1901.

Experiments in the transmission of a visual image were being conducted in Germany, the US and France and, though the experiments did not reach a practical stage for many years, a scanning disc for transmitting pictures had been patented in Germany in 1884. Photography was well developed and devices both for taking and for projecting motion pictures had been introduced. Thomas A. Edison's 'kinetoscope' in which a series of pictures whirring past a peephole gave the impression of motion had been offered as an entertainment attraction in 1894; the Lumière brothers had designed a 'cinematoscope' and Thomas Armat's 'vitascope' had projected these pictures to a screen in 1895. A number of methods had been developed for recording

sound by means of grooves cut in the surface of a cylinder or disc and reproduced through a needle which activated a diaphragm; Edison had received a patent in 1877 and by 1897 the manufacture of records had become a commercial success.

It required much research and development, however, to produce the modern telephone from the crude instrument which could carry the voice clearly only short distances, to change the wireless from a vehicle for transmitting dots and dashes into a medium for carrying the modulations of voice or musical instrument, and to bring the scanned picture or live event on to the television screen.

Many of the basic devices which were to permit the sounds and images not only to be transmitted but handled economically in great volume were also known or envisaged and had been put to use in telegraph and telephone systems. The essential problems were to connect the right sender with the right receiver, to carry many different messages simultaneously over a limited number of wires or air-waves, and to do this swiftly, accurately, if possible automatically, and without excessive cost.

At the opening of the century the manual telephone switchboard with cords to connect the calling and receiving lines was already in use, with multiple termini for each line to the appropriate socket in each operator's panel, signal lights to indicate that a line desired a call and busy signals to prevent two operators from plugging into the same line. Automatic switching, using the electromagnetic principle which continued to form the basis for automatic switching up to the 1950s, had been developed experimentally and put to limited commercial use in 1892. (Pl. 16a, 16b.)

Methods for carrying extra circuits on the same wires had also been developed. The 'phantom' or third circuit carried by two pairs of wires with each pair of wires serving as a side of the phantom circuit was worked out in the 1880s. The 'carrier' principle, which made it possible to use frequencies above the voice range to carry the voice signals, was applied to telephony by French inventors in the 1890s, although the principle was not put to commercial use until 1918. British scientists had studied the special transmission properties of the coaxial circuit, i.e. a copper tube with a single wire centrally supported within it.

The great technical improvements in communication came about gradually and steadily during the twentieth century. These developments lengthened tremendously the distances through which the voice could be transmitted clearly, improved the quality of transmission, permitted the transmission of visual images as well as sound, increased the number of messages that could be carried over a single route in a given time, provided increasingly elaborate interconnections among senders and receivers, made operations automatic and reduced cost.

While much of the development involved the refinement of the basic nineteenth-century inventions, one new invention was of revolutionary

significance, the three-element electron or vacuum tube invented by Lee De Forest in 1906. This tube, by amplifying a very weak current, made it possible to reinforce telephonic impulses as they were carried over long distances, to magnify radio waves to audibility and to receive television and radar images and sonar echoes. By the 1950s a second revolutionary invention, the transistor, developed by W. J. Brattain and John Bardeen in 1948, was beginning to open yet another stage in the development of swift and economical communications. This tiny amplifier, using differences in atomic structure to create an electron current, performed the functions of the vacuum tube without heat and thus with only a hundred-thousandth of the power required by the latter. It permitted the construction of electronic apparatus of miniature size.

The various technical developments in the fields of communication were closely interrelated, whether they involved telegraphy, telephony or radio broadcasting, transmission by wire or air, or the reproduction and transmission of visual images or sound.

It was the vacuum tube which first effectively conquered the problem of distance. By 1914 the original De Forest tube had been improved to the point where it could be used for repeaters inserted at frequent intervals in a line to amplify the current and pass it over the next segment. The length of a wire circuit could thus be extended indefinitely, with no loss of volume. By this means a coast-to-coast telephone circuit across the United States was opened in 1915. Long-distance communication by air was established simultaneously. Transocean radiotelegraph service from San Francisco to Honolulu was inaugurated in 1912 and in 1915 listeners in Paris and Hawaii heard a voice speaking from Arlington, Virginia, USA.

There remained however the problem of distortion. As sound travels distortions may come in and be amplified by each repeater. The invention in 1927 of a device for reducing distortion known as the negative feedback was second in importance only to the vacuum tube itself in permitting voice or music to travel great distances without losing its original quality. Many other devices to suppress distortion contributed to the continuous improvement in the fidelity with which sound could be carried over great distances.

The revolution in communication came into full force in the 1920s. Radio broadcasting dates from 1920 when a Pittsburgh, USA, station broadcast the results of the presidential election. A commercial overseas radiotelephone was opened between Britain and the United States in 1927 followed within five years by services from Germany, Britain and the United States to South America, from Britain to Australia, and from the United States across the Pacific to Japan and the Dutch East Indies. Radiotelephone service to ships at sea was inaugurated in 1920 and became common not only on ocean liners but on many small vessels in coastal waters and on lakes and rivers. The first round-the-world telephone conversation was conducted in 1935. Radiophones became indispensable in both civilian and military aircraft.

The electrical transmission of visual images also reached the level of

commercial use at the same time. By means of a light-sensitive electronic cell used to scan a picture and the transmission of the resulting electrical impulses, pictures were 'telephotoed' from one point to another by either wire or air. Pictures began to be sent across the Atlantic in 1924 and thereafter the world's press carried news pictures of distant events as promptly as the stories to which they referred. Successful experiments also established the feasibility of television. After considerable study and experiment in Great Britain, the United States and Germany, the basic patent on the iconoscope, or television camera tube, was issued in 1923. Television programmes were broadcast experimentally in these three countries from 1927 on, some for public reception in these countries and the USSR in the 1930s.

Later developments steadily improved and elaborated all these techniques. For radiotransmission, frequency modulation supplemented the older method of amplitude modulation in the 1930s. For both radio and wire transmission it became possible to utilize higher and higher frequencies, thus exploiting the potentialities of the transmission media much more fully. Television apparatus for both sending and receiving was entering commercial use on the eve of the second world war, and after the war television sets spread like wildfire not only in the USA, Canada and Great Britain, but in Europe, USSR, Japan; within ten years television was introduced in Australia, Latin American countries, Thailand, the Philippines, Algeria and Iraq, and colour transmission began.

Progressive improvements in vacuum tubes made more accurate, dependable and economical all the forms of communication which depended on this essential device. The tube's life was lengthened from six weeks to more than ten years and the power required to heat the filaments was reduced to one-tenth of that required in the early models. When the transistor began to replace the vacuum tube in the 1950s, the far greater durability and economy of this tiny instrument promised to make all types of long-distance communication still less costly and more sure.

II. EXPANSION IN THE USE OF COMMUNICATIONS MEDIA

The use of each new means of communication expanded at an astronomical rate. From the moment of its introduction the telephone grew by leaps and bounds. In the 1950s at least a dozen countries had over a million telephones each. In proportion to population the best-supplied countries were the United States with one telephone for every three persons, Sweden with one for every three and a half, and Canada and Switzerland with one for every four persons. Canada led in the amount of use made of the telephone system, with an average of 418 calls per person in 1954 as compared with 393 in the United States and 334 in Sweden. In 1954, 56 per cent of the world's 91,000,000 telephones were in the United States and the number was still growing rapidly, but the fastest rate of increase during the preceding five years had been in Asia and South America.

By 1953 international wire telephone circuits connected the European countries and many non-European countries or territories. Some 180 countries and dependencies were linked by point-to-point radiotelegraph channels and 110 were joined by radiotelephones. Telephone wires were laid under the Atlantic in 1956.

Radio broadcasting, inaugurated early in the 1920s in the United States, Great Britain and Germany, spread rapidly through Europe, the USSR, the British Commonwealth and Japan. By the late 1940s only a few remote islands and African territories lacked a local broadcasting service. In 1955 radio sets for the first time outnumbered copies of daily newspapers sold around the world; radios numbered an estimated 257,000,000 and newspapers 255,000,000. The greatest concentration of sets was in the United States, which had half of the world total or some 760 sets per 1,000 of the population, two and a quarter times the number of copies of the daily press. The number of radios also exceeded the copies of the daily press in Canada, Mexico, several Latin American and Caribbean areas, and in a number of African areas where literacy was low and newspapers scarce. European press circulation exceeded the number of radio sets except for Austria, Czechoslovakia and Hungary, as was also the case in most of the countries of Asia.

But there were over 215 sets per 1,000 people in Australia and New Zealand, 185 in Europe, 95 in the USSR, 60 in South America, 15 in Asia and 10 in Africa. Moreover, the number of sets was increasing rapidly in the less well-supplied areas of Africa, South America and Asia. The UN Conference on Freedom of Information in 1948 adopted a resolution saying that 'the possession of receiving sets is necessary to assure a really free flow of information and is in no way a luxury'.

Television's rate of growth was even more spectacular. In the decade after the second world war more than 30 countries put regular television service into operation, and by 1955 some 45,000,000 TV receiving sets were in use. Although four-fifths of these were still in the United States, TV services extended to nearly all parts of Great Britain, where there were 4,000,000 receivers, eight European countries participated in a programme exchange network known as Eurovision, the USSR was rapidly expanding the number of its stations and was regularly broadcasting all its first-run films to more than 700,000 receivers largely in clubs and centres, and Japan's stations and sets mushroomed from their start in 1953. TV was expanding more rapidly even than radio in Latin America and it was passing beyond the experimental stage in one country after another in every continent.

The spectacular increase in the volume of communication by telegraph, telephone, radio and television depended upon developments which permitted many messages to be carried simultaneously over the same route and which made their routing automatic. Phantom circuits increased the capacity of each four wires by 50 per cent, but carrier systems modulating the voice to a series of different higher frequencies were able to carry as many as sixteen

simultaneous telephone conversations on a single pair of open wires and many more on cables. The coaxial circuits, introduced in Germany and the United States in the 1930s, used very much wider frequency bands, extending over as

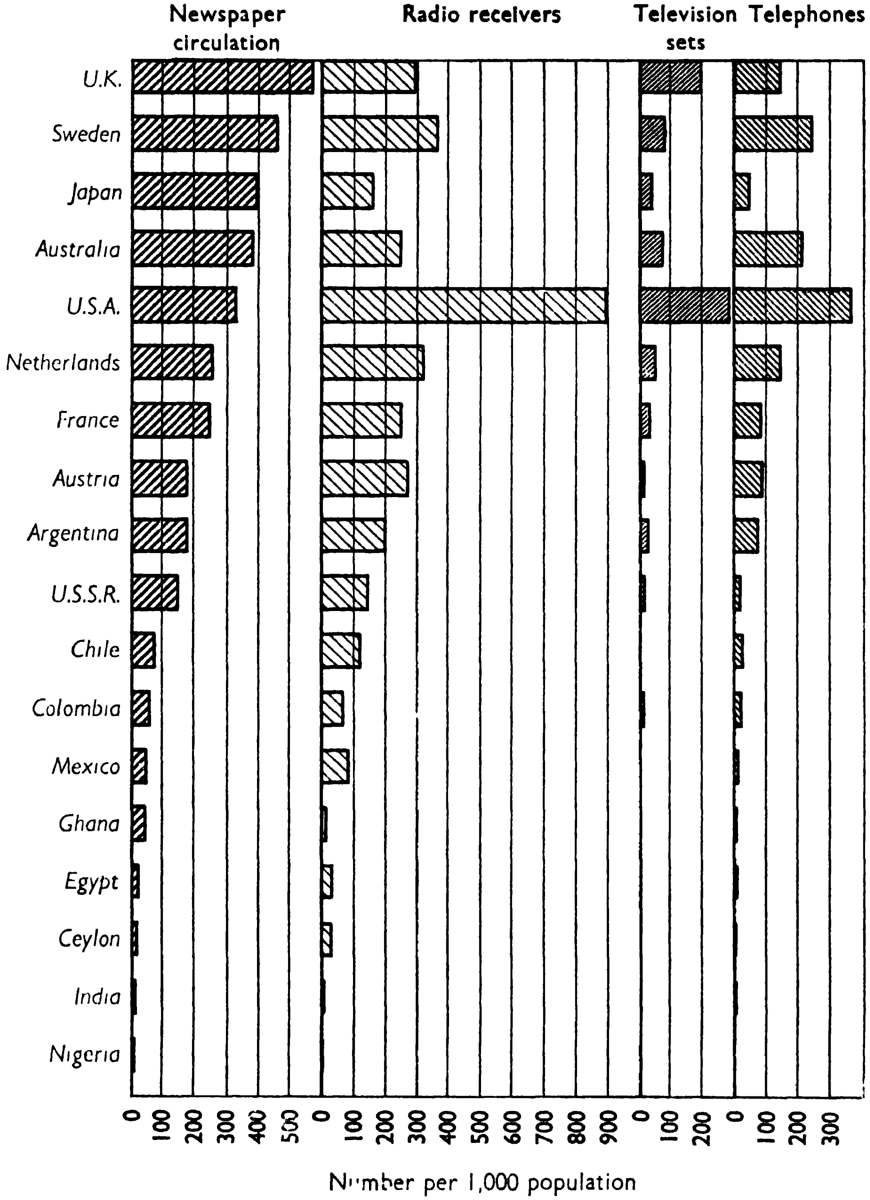


CHART XIV. Press, Radio, Television, Telephone, Number per 1,000 Population. Selected Countries, 1958.
Source: *U.N. Statistical Yearbook*, 1960.

much as three megacycles (3,000,000 cycles) per second, and provided as many as 600 two-way voice channels on a pair of coaxials. Improved coaxials introduced in 1952 provided a frequency band of nearly eight megacycles and could carry 1,800 telephone channels or 64,800 one-way telegraph messages on a single pair. Microwave radio beams, travelling like a searchlight in a direct line-of-sight path, were used for voice transmission across the English Channel in the early 1930s. By 1951 a microwave radio-relay system beamed between a succession of high points across the United States provided 3,600 telephone channels in each direction. The hollow wave-guide conductor which would transmit wave bands up to thousands of megacycles was in an experimental stage by 1955.

The coming of television placed a heavy load on transmission facilities, for each television circuit required the equivalent of 600 telephone or telephoto circuits. Coaxial circuits capable of transmitting 1,800 telephone conversations simultaneously could, instead, carry three television circuits in each direction and the 3,600 circuit radio-relay beam could carry six. The demands of television stimulated the expansion of multi-channel facilities.

With these developments, the use of wire or air for transmission became almost interchangeable. Telephone calls were necessarily based on radio-transmission when made to or from moving vehicles, such as police cars, taxicabs, trains, ships or planes. But in spite of the existence of regular radio-telephone service across the Atlantic for nearly thirty years, the first transatlantic telephone cable, equipped at 40-mile intervals with vacuum-tube repeater-amplifiers designed to operate at the bottom of the sea for twenty years went into operation in 1956 and similar cables were being laid from the west coast of the United States to Alaska and Hawaii. Such cables were designed to avoid the atmospheric disturbances that sometimes interfered with communication by radiotelephone as well as to increase the number of channels. Of the eight complete transcontinental paths by which telephone messages could be carried or radio and television programmes relayed across the United States in 1954, four were principally open wire routes, two were wire cables, one was a coaxial cable and the eighth was a microwave relay. Many radio listeners in Europe, especially where atmospheric conditions often made radio reception poor, as in Switzerland, tuned in through a set attached to their telephone on programmes broadcast over the air, picked up and piped to their sets by wire. Wired reception was widely used in the USSR and eastern Europe.

The multiplication of communication channels and of the number of persons using them enormously complicated the problem of connecting the right sender with the right receiver and made the development of successful automatic switching imperative. Without automatic switching the US telephone system would have required half a million operatives to man the switchboards by the 1950s and other countries with a high *per capita* telephone service would have needed corresponding numbers. By the mid-1950s 77

per cent of the world's telephones were automatic as compared with 15 per cent in the 1920s, and most of the telegraph messages between major centres were handled automatically. While the bulk of automatic telephone switching was for local calls, direct long-distance dialling was rapidly joining local automatic operation.

A wide variety of switching mechanisms was developed and put into use in different countries, the most flexible and widely adopted being the cross-bar system. The objective in automatic switch design was to develop devices which would take an incoming message, determine quickly what circuits were open, make the connection and then return to position ready to serve the next call while the first was still going on. Automatic recording devices were also necessary wherever an individual charge had to be made for the call or message. Virtually all automatic switching systems continued to use electro-magnetic devices, although electronic devices could perform the same functions more rapidly. Because of their bulkiness, power consumption, tendency to wear out and less than complete reliability, vacuum tubes were not used in switching mechanisms. The transistor, however, had none of these disadvantages and could be used for instantaneous electronic selection comparable to that in an electronic computer.

The advance in technology and great expansion in volume brought spectacular reductions in the cost of communication, especially over long distances. It cost one-seventh as much to call from coast to coast across the United States in the 1950s as it had in the 1920s; in dollars of comparable value it cost less than a tenth. The reduction in cost was largely a product of the great multiplication in the number of circuits carried over the same medium, for the larger the number the lower the cost per circuit. Lower costs for the complicated equipment required at each end of a carrier system to transpose the voice to high frequencies and then to restore it to normal further contributed to general reductions in cost. So long as the terminal equipment was very costly, carrier systems with their multiple circuits could only be used for long distance. With lower terminal costs, carrier systems became practicable for short-distance and rural circuits and for inter-office trunk lines in metropolitan areas. The costs of radio and television receiving sets dropped with both mass production and technical improvements. In some places, receiving sets pre-tuned to a single or limited number of wavelengths were made and distributed at especially low cost in connection with radiodiffusion educational programmes or to permit the reception of official broadcasts.

III. USES OF COMMUNICATIONS MEDIA

The communications systems were put to a myriad of uses. In addition to placing the twentieth-century individual in contact with other individuals, on his own or their initiative, they exposed him to vast bodies of material brought to him for an endless range of purposes.

Communications media were as essential as machinery to the carrying on of a business. By telephone, customers placed orders and companies made sales and reports; managers received and issued instructions; headquarters offices could know at all times what was going on throughout an organization; a bank could compare a signature by telephoto; a factory manager could observe the works by closed-circuit television; a taxi-cab dispatcher could direct a fleet of cabs in response to calls; a spotting plane could guide fishermen to schools of fish. Every form of telegraph, telephone, radio and television was built into the structure and daily operation of every sort of business, government and military activity, and into the lives of people.

Besides serving constantly in the daily routine the media of communication provided an emergency resource of greatest importance. Police could be summoned to the scene of an accident or crime or could broadcast the description of a fugitive; a sheep farmer at a lonely Australian station could summon a doctor of the flying medical service; a ship in distress could call for aid. The ability to maintain communication made scientific bases practicable in the polar regions; arctic expeditions no longer vanished into silence, to emerge months later or fail to return.

By means of the rapid communications techniques a world-wide network for the collection and dissemination of news kept the people of the world constantly informed of what was happening everywhere. In addition the use of the mass communications systems to create and maintain a mass market subjected the twentieth-century individual to an endless stream of advertising especially in the countries where radio and television operated commercially.

The mass media also provided a channel for mass education, both when they were deliberately used to supplement the more usual forms of instruction and as the by-product of broadcasting for entertainment or other purposes. They placed a powerful instrument of propaganda in the hands of governments which chose to use their communications systems as instruments of control. They provided a large part of the entertainment which twentieth-century man came to enjoy and furnished the basis for vast new entertainment industries. They played their part too in the shaping of twentieth-century artistic expression, both by the instruments which they placed in the hands of producers and in the mass audiences which they reached.*

IV. COLLECTION AND DISSEMINATION OF NEWS

The public function most intimately bound up with the systems of communication and responsible for much of their expansion was the collection and dissemination of news. The instrumentalities for this purpose constituted

* For discussion of the communications media as sources of entertainment see Chapter XXVII, Leisure; for their educational role see Chapter XXVI, Education; in relation to the arts see Chapter XXXI, Literature and the Arts.

one of the most central, multi-faceted and powerful institutions in twentieth-century life.

1. *News channels*

The world's news travelled over telegraph and telephone networks, by international submarine cables linked to these networks and by radio communication systems, both point-to-point radio telegraph and telephone channels and radio broadcasts beamed to broad areas. News pictures were conveyed by telephoto and television.

Areas differed greatly, however, in the number of communications channels which were available, the cost of using them and the way in which their use was regulated. All of these factors affected the volume and kind of news originating in and reaching different parts of the world.

London was and remained the principal centre through which news flowed by reason of the early leadership assumed by Britain in laying down cable links, the wide connections with empire and commonwealth areas, low telegraph and cable rates, the extensive coverage of the British news-gathering agency, Reuter, and the use of London as the European distributing point by North American news services. American and French facilities and services were next in extent and range. The USSR maintained extensive internal and external facilities and an organization for both the collection and dissemination of news. Germany, whose international news service had been one of the oldest and best established at the opening of the century, lost its position as a news centre during the first world war.

In general the European and North American centres of population were much better equipped with facilities for the collection and dissemination of news than less industrially developed regions, although by mid-century very few areas were wholly lacking in wire or radiotelegraph or radiotelephone connections over which news could be transmitted to and from the outside world. Most of the modern cables that provided many circuits and could carry the voice, as well as most of the teleprinter and telephoto circuits, the extremely rapid, electronically operated telegraph equipment, and the principal radiotelegraph and radiotelephone connections, linked the major centres.

Many non-industrial areas remained without sufficient communications channels to permit an adequate dispatch and receipt of news. Limited telegraph systems equipped with slow hand-keys continued to offer the only wire link to a number of non-industrial areas. Up to the middle of the century such countries as Burma or Liberia had only one or two links with the outside world, although many of the less well-served countries were rapidly expanding their radiotelegraph and telephone services. During the period after the second world war several of the countries of Latin America and the Middle East increased their international links more than tenfold in the course of five years.

Within each country collection and dissemination of news depended on internal communications networks which differed greatly in their adequacy. The major centres and many minor points in the UK, USA, European and Commonwealth countries were linked by teleprinter, telephone and radiotelegraph services. Most industrial countries depended on teleprinters for the transmission of a large proportion of their news, but the USSR relied chiefly on radiotelegraphy. Most other countries, as well as the vast majority of non self-governing territories, lacked adequate teleprinter services or other two-way means of transmitting news rapidly within the country. In the absence of such internal lines of communication, news sometimes did not penetrate beyond the capital city and most of what reached the outside world originated there.

The inadequacy of established international and internal channels was partly overcome by the direct-voice broadcasting of news to areas which lacked wire or point-to-point radio communication. Here again London remained the principal news centre. The British Broadcasting Corporation beamed news broadcasts overseas which any listener with a short-wave receiving set could hear; in the 1950s it was sending out these broadcasts in some 46 languages. News broadcasts from other sources, however, began to reach many areas after the second world war. Moscow radio sent out foreign broadcasts in 35 languages and radio-Peking was also heard beyond its national borders; the Voice of America broadcast in some 38 languages, the Italian radio in 34 and Vatican City in 25; radio-India used one of its 3 major transmission facilities for news broadcasts to Asia and Africa in a dozen languages; radio-Cairo reached parts of Africa and the Arab countries; broadcasts in a dozen or more languages also went out from France, Spain, Hungary, Czechoslovakia and Turkey, and in a smaller number of languages from Belgium, Bulgaria, Austria, the Netherlands, Canada, Israel and elsewhere. How widely these broadcasts were heard depended on reception facilities. Where receiving sets were few or where wired redistribution systems or sets pre-tuned to certain wavelengths were extensively used, foreign broadcasts could not penetrate to many listeners.

Within countries, radio news broadcasts supplemented other methods of news dissemination; they became the principal news channel where other communication facilities were inadequate, the press was not well developed or literacy was low. News broadcasts by the national radio service were picked up by the press, as in India where local papers depended on the radio-India broadcasts for much of the news which they printed. In many countries radio news was listened to in villages where no printed press existed. But although news broadcasting could disseminate news to places where facilities were otherwise inadequate, it could not solve the problem of news collection. Where two-way channels were lacking, news might flow in but it could not be gathered and sent out.

The content of news tended to be heavily weighted with material originat-

ing in the major centres. One of the problems which most concerned Indian journalists, for example, was how to develop a flow of news from neighbouring Asian countries instead of relying so heavily on the usual sources of foreign news which supplied a disproportionate amount of news from Europe. Not only the source but the point of view tended to be that of the established centres. The nature of the vast news-generating and distributing machinery meant, inevitably, that those who controlled it set their stamp upon the content, whether consciously or unconsciously. The international news services were especially important in this respect.

2. *News agencies*

The international collection and distribution of news was in the hands of a few great news services. At the opening of the century four of these agencies divided the world among them. Reuter of Great Britain gathered news originating in the British empire, the Far East and Egypt, and supplied these areas with news from abroad; Agence Havas of France covered the French empire and Latin America in the same way; Wolff of Germany supplied news to and from the rest of Europe; the Associated Press of the United States operated in North America. These four agencies, which had come into existence with the development of the telegraph and the commercial press in the middle of the nineteenth century, exchanged news by mutual agreement and redistributed it to the areas which they served.

The pattern of exclusive areas began to break down during the first world war when Reuter and the Associated Press invaded areas formerly served by Wolff and Havas, and it was completely destroyed in 1934 when the Associated Press refused to renew its agreement with Reuter on the ground that competition in supplying news to all areas would mean better service for all. At mid-century six world news services operated competitively: Reuter, Havas which was re-established in 1944 under the name Agence France-Presse, the Associated Press and two additional US services, United Press and International News Service which had been established in 1906 and 1907, and the Soviet news agency, Tass, set up in 1918 under the name Rosta. All or most of these services maintained offices in each of the major news centres around the world, such as London, New York, Washington, Paris, Rome, Berlin, Stockholm, Moscow, Istanbul, Tokyo, Hong Kong, Delhi, Manila, Cairo, Buenos Aires, Rio de Janeiro. Each agency, however, remained the principal provider of news to and from its area and in localities where the political or cultural influence of its country was strong. A few areas were served by only one of these services—parts of Africa by either Reuter or AFP, parts of Central and South America by the three American services, China, Outer Mongolia, North Korea and East Germany by Tass. Some combination of Reuter, AFP and one or more of the American services reached most places, with the addition of Tass in eastern and western Europe, the USA and some parts of Asia.

These news services maintained their own foreign bureaux and correspondents for the direct collection and distribution of news. In addition they had agreements with press agencies in most of the countries where they operated by which these agencies supplied news from their area and in some cases distributed to their member papers the news furnished by the international services.

After the first world war Reuter began to use radio to speed up the receipt and distribution, first of commercial information and then of general news, and other news agencies followed suit. By December 1929 continuous service of general news was being broadcast by Reuter to Europe and by Havas to South America and the Far East, and after 1934 by Reuter to the East and to Africa.

At mid-century Reuter was transmitting 90 per cent of its news by 'Globereuter' service on seven radio beams whose combined spread covered nearly the entire world. The other major news agencies made less extensive use of radio than Reuter. The United States agencies, however, expanded their use of radio after rates were reduced in 1946, the French agency became a large distributor of news by multiple-address radiotelegraph, and a number of other European and non-European countries utilized similar services. In some areas, however, no reception or distribution facilities for this type of service existed, sometimes as a matter of censorship and sometimes because the costs of reception made it unavailable to those who needed it most.

As the elaborate system of world news gathering and dissemination evolved, national press associations were formed in one country after another to serve or control their national press and to tie into the world network. In most European countries, the USA and Japan, national press organizations had been formed before the opening of the twentieth century. By mid-century they existed also in the principal Asian countries, several countries in Latin America, and the Sudan and the Gold Coast (Ghana) in Africa. In some countries, notably the United States, the national press associations were independent associations of newspapers; more generally, they were linked to the government or were official monopolies. In the many countries where the national press services received and distributed news from international agencies they determined the relative use made of one or another of the world sources.

3. *Change in character and content of newspapers*

With the spread of mass literacy the number, variety and circulation of the world's newspapers expanded until the circulation of daily papers in 1955 amounted to one-tenth of the total world population. Great Britain led in rate of newspaper circulation, with 6 papers sold daily for every 10 men, women and children in the country, followed by the Scandinavian countries, Australia and New Zealand, Japan, the USA and the other countries of western Europe. Newspaper growth was not limited to highly industrialized

countries, however, but took place in areas where literacy was only beginning to spread. By 1955 the Gold Coast had 11 dailies with a total circulation of 75,000, 9 weeklies and a local news agency, and Nigeria had 13 dailies with a circulation of 92,000.

Newspapers ranged in tone from the staid reporting and modest headlines of *The Times* of London, its news discreetly hidden behind a front page of classified advertisements, to the screaming headlines and dramatic pictures of popular tabloids such as the *New York Daily News* and the lively sensationalism of the London *Daily Express*. Their editorial viewpoint reflected a range of political opinion. Though papers of all types flourished, the most spectacular growth was in those which offered a mass appeal by catering to the tastes of a broad body of readers. *The Times*, with 235,000 daily circulation, appealed to essentially the same educated public that it had reached in 1900, while the *Daily Express*, which Lord Beaverbrook had started to modernize in 1913, provided news and especially entertainment in 1950 to over 4,000,000 people, one-quarter of all Britain's avid newspaper readers.

The spread of mass literacy and education also changed the character of what constituted news. By the opening of the century the newspapers of the major cities were already losing their traditional character as purveyors of opinion and information on political, diplomatic, local and financial topics for a limited range of readers, and were starting to become sources of information on the multitude of subjects that the mass of readers regarded as news. In the following decades the news media, catering to wider publics for whom many assorted kinds of information were news, covered large new areas, of interest to both new readers and old.

As the century progressed the news came to reflect the tremendous expansion of industry; especially after the economic collapse of 1929, economic problems and the relationship between industry and government became central topics. It reflected, too, the growth of urban populations and related questions of ways of life in cities, the conflicts of labour and capital and of social and racial groups and new developments in education. Reporters presenting news of new discoveries in science made an effort to bridge the gulf between experts and laymen. News of sports, always a popular subject, occupied much space in the press of all countries; in the 1950s, for example, Agence France-Presse had nearly four times as many subscribers to its special racing news service as to its special stock exchange news. Closer world contacts made foreign peoples seem of more immediate concern to the ordinary individual.

Newspapers of all levels covered this wide new range of material. Papers which served a more educated public carried a substantial proportion of serious reporting on all of these subjects and increased their demands from the world news agencies for explanatory or background material on world events to supplement the spot news which had once been considered adequate. The papers which catered to a mass audience prided themselves on their

succinct coverage of news and their treatment of cultural and scientific developments, but they carried less background material explaining world events and economic problems and filled their columns with more of the crime, sex and accident news and gossip which made a sensational appeal.

The cost of the collection and distribution of news was high, and grew higher as the areas of the world and the subjects to be covered became more numerous and complex. It took more and more subscribers to support a full-scale newspaper, and the press had therefore to serve the demands of many publics in order to survive. Even a large circulation, however, became an insufficient financial base, and in the countries where the press was privately owned it came increasingly to depend on advertising.

At mid-century advertising provided as much as 70 per cent of the income of the average newspaper in the United States. Advertisements occupied up to two-thirds of the space in some of the mass-circulation dailies in North and South America, more than half in some popular British Commonwealth journals, about a third in the popular journals of west Europe and 40 per cent in Japan. In the less popular journals of more limited circulation the proportions were lower.

The advertisements themselves were one form of news, as readers looked to them for information on what was available to buy and also for an indication of the changing tastes, fashions and standards of life of their society. The relation between circulation and advertising was reciprocal: a large circulation attracted advertising and permitted the charging of high advertising rates. The costs of newspaper publication thus tended to favour the papers which were able to achieve mass circulation, and pressed publishers in the direction of editorial policies and newspaper content which would attract and hold the widest range of readers.

The costs of transmitting news generally favoured the areas already best served. Telegraph and cable rates were usually lower in the industrial countries with ample facilities and a large volume of business than in countries with less adequate facilities and without mass use. Press rates reflected this difference, for they were ordinarily based on rates for commercial messages; for the countries acceding to the international agreement of 1949, they amounted to one-half. London enjoyed a special advantage, for British commercial rates were lower to most points than those of other countries, and a special press rate of a penny-a-word prevailed throughout the British Commonwealth after 1941. In general the rates from the less developed countries were so high as to discourage the transmission of full news reports.

In areas of low literacy and low newspaper circulation, in fact, the main problem was keeping the press alive at all, let alone supporting the costs of effective domestic and international news services. This was recognized as a world problem by international organizations, and was one of the central matters to which Unesco addressed itself. As new nations took their places in the international community and other non-European countries became

increasingly active in world affairs, the need for adequate, balanced news services in these areas became acute. At the same time the industrial countries with full local news services needed greater knowledge of the areas where news facilities were poor.

In the effort to assist in the meeting of these problems Unesco conducted a world-wide survey of the press, radio, television and film facilities of each country, prepared manuals and offered scholarships for the professional training of journalists and of radio and film technicians, examined the legislation affecting the status of news media and the free flow of information and co-operated with the International Telecommunications Union in the latter's effort to improve the procedures and lower the costs of communication. It worked with the FAO to stimulate the production of newsprint and its equitable distribution, promoted international agreements for the free flow of information, and provided technical assistance to countries requesting help in developing their press and communications systems.

The difficulties encountered by the developing countries were further complicated by the shortage of newsprint. Canada and the USA, with less than 10 per cent of the world's population, consumed 70 per cent of the world's newsprint. Europe, with a substantially larger population and a higher percentage of newspaper readers, consumed only a third as much, while the volume of available newsprint was extremely limited in Asia, outside of Japan, and was negligible in Africa and the Middle East. By mid-century, the FAO had begun a long-term programme to open up new producing centres, in the hope that decentralized production would facilitate the provision of newsprint and help to provide paper in the areas where it was very scarce.

4. *Freedom of the press: news, propaganda*

Prior to the first world war the gathering and dissemination of news was carried on as a private enterprise. Individual papers were everywhere operated commercially or as the organ of an individual or political group, and the wire services were run as private ventures like Reuter or, like the Associated Press, as a co-operative undertaking by a number of papers. The press of the principal centres enjoyed and jealously maintained freedom from government censorship or restraints other than those generally imposed by laws of libel, fraud or obscenity.

During the first world war governments began to enter the news field. In total war, public attitudes were hardly less important than arms; propaganda and censorship became essential aspects of the war effort. The radio offered a new means of reaching many receivers and was used by various belligerent governments for propaganda purposes. When Germany was cut off from its regular news contacts with the rest of Europe the German government set up a radio service, Transocean News, in 1915 to bring the German view of events to the outside world. Trans-ocean broadcasts, picked up by German embassies or other outposts, were relayed to the local press in the countries

where they were received. Other belligerent governments in one way or another enlisted their press facilities, and to a limited extent their radio, for the promotion of the war effort.

A politically motivated struggle to command the minds of men was thus added to what had been a commercially motivated contest for the provision of news. From the first world war onward the media of communication were used for both purposes. On the one hand the press of the liberal democratic countries and the news agencies which served them made objectivity and accuracy in news reporting their goal and they achieved a high level of competence in these respects. But where authoritarian forms of government prevailed, control of the flow of news and the use of news media to advance the objectives of the régime was everywhere a basic procedure. One of the first steps which dictators took to secure their power was to suppress the free press, as was evidenced in the famous example of the Argentine paper, *La Prensa*, suppressed by the dictator Juan Perón, and re-established immediately upon his fall. With alternative sources of information cut off, such governments used their news media to present a single official version of all important events.

The United Nations Universal Declaration of Human Rights declared: 'Everyone has the right to freedom of opinion and expression; this right includes freedom . . . to seek, receive and impart information and ideas through any media and regardless of frontiers' (Art. 19). A United Nations conference on freedom of information held at Geneva in 1948 attempted to spell out, in a series of resolutions and draft conventions, the necessary conditions for the exercise of this right. It specified in principle the right of news personnel to have access to sources of information, to travel unhampered, to transmit their copy without censorship or delay and to have news material from all sources admitted on equal terms.

The basic strength of the free press came from the rank and file of newsmen who kept the great mass of news flowing. In order to cope with the swift methods of communication and the increasingly wide and complex fields of news, press and radio required a large body of highly competent reporters whose job it was, day in and day out, to cover the whole range of news, bringing to the smallest story or the biggest a workmanlike capacity to recognize a news event, pursue information relentlessly and present it clearly, correctly and simply.

As the content of news became more complex, newsmen needed more and more background in order to understand the significance of what they saw and heard. Some reporters specialized in particular fields such as science, economics or sports, or in particular regions, in order to be in a position to present news stories well-buttressed with soundly selected background data necessary to an understanding of the immediate event. Schools of journalism were established at university level to provide men and women with the broad education and professional training which their task increasingly required.

Although newspapers and radio were uneven in the quantity and quality

of the news which they offered, they responded generally to the demands of a better-informed public with a better-informed press. At their best the free press and radio offered the reading and listening public the opportunity to become informed on an ever wider range of current developments.

At the same time the use of press and radio to manipulate readers and listeners and mould their opinions, attitudes and desires becomes a highly developed art. In sharp contrast to the goal of accuracy and objectivity in news reporting, propaganda sought to use all the devices suggested by ancient experience and modern psychology to focus attention, arouse emotions of fear, prejudice, anxiety or desire, and by slogan, symbol or other appeal to command an uncritical response. Adolf Hitler enunciated the concept of the 'big lie' which, by its very preposterousness, undermined reason, developed uncertainty and then led to acceptance. By such means governments sought to assure the allegiance of their people; political leaders endeavoured to influence their followers and as many of their opponents as they could; advertisers resorted to similar devices as they refined their techniques for stimulating the desires of potential purchasers and promoting sales. 'Public relations' became a recognized skill and experts were employed by businesses, organizations, agencies and public figures to arouse a favourable public response.

But although news reporting and propaganda were aimed at different, often opposite, objectives the line between them was not always clear. The way in which newspaper editors handled the news could hardly fail to affect attitudes and opinions of readers. Some news items were featured and others passed over; captions directed attention to particular points; the speech of one political candidate appeared in a more conspicuous place than that of his opponent; editorials, cartoons or signed commentaries highlighted points in the news and gave a slant to its meaning. Even the papers which laid greatest stress on objective news coverage, such as the London *Times*, *New York Times* or Manchester *Guardian*, were necessarily selective in what they printed. Reporters provided greater detail on the stories which they thought their paper would use.

The line between reporting and propaganda was also blurred in respect to the collection of news. From the first world war onwards governments began to maintain press bureaux to supply information and statements on public issues to the press. Private bodies that wished to make a favourable public impression, such as corporations, labour unions or other institutions, also set up press offices and gave out news. Government officials and others in power were often tempted to control the facts issued in terms of their notion of what was good for the people to know, or for the bargaining position of the nation or for their own position. This resulted on the one hand in a variety of forms of censorship, both informal and official, and on the other in constant efforts by responsible men of the press to uncover the needed facts and assure freedom in transmitting them.

During the second world war news reporting was far more extensive than during the first world war and the inter-war years, as radio, especially, was used to keep the people of the belligerent countries constantly informed of day-by-day, even hour-by-hour developments on the far-flung battle fronts and to penetrate behind enemy lines. The news broadcasts of the British Broadcasting Corporation reached the people of occupied European countries and bolstered their morale when other means of communication were cut off.

Propaganda also was greatly intensified. Belligerent countries set up agencies to engage in psychological warfare by sustaining the spirit of their own side and undermining that of their enemy, beaming radio programmes both to their own people and abroad and, especially in occupied areas, trying to prevent reception of foreign news by suppression of receiving sets or by 'jamming' the air with conflicting sounds. In the cold war which divided the world in the years after the second world war the importance of radio as an instrument of propaganda was evidenced by the extensive external programmes sent out by governments of all sides and by the measures taken to prevent reception from outside by means of jamming.

These opposing trends were reflected in the failure of the United Nations to reach an agreement as to the proper role of government in respect to the control of information. Fundamental differences of view prevented the General Assembly from adopting the conventions proposed by the 1948 conference on freedom of information.

On one side the countries with a tradition of press freedom took the position that the interests of society were best served by free access to the marketplace of news and ideas, and that interference by government should be limited to the minimum required by decency and security. On the other hand the socialist countries, proceeding from their class understanding of the freedom of the press, adopted a stand which in their view permitted the pursuit of social goals by more realistic means. The USSR maintained that, in the words of Lenin, 'the freedom of the press is a delusion so long as capitalists commandeer the better printing establishments and the largest stores of papers and capital retains its power over the press'. It regarded publication facilities as elements of socialist property. Freedom of speech and of the press were, according to the Soviet delegate, 'guaranteed by the state upon the sole condition that they be utilized in accord with the interests of the toilers and to the end of strengthening the socialist social order' and were denied to the foes of socialism, and 'every sort of attempt on their part to utilize to the detriment of the state—that is to say, to the detriment of all the toilers—these freedoms granted to the toilers must be classified as a counter-revolutionary crime'.*

Both groups disapproved of the language proposed for the draft convention on freedom of information and for a code of ethics. The Soviet delegates

* *Freedom of Information* (United Nations Economic and Social Commission, 1953), p. 3.

objected on the ground that it failed to set forth positive obligations on the media of information to work for the cause of peace and to combat 'the remnants of fascism'; the delegates from free-press countries objected because it imposed some obligations and restrictions on the media of communication beyond the primary duty of the press to publish accurate information.

In addition many of the new countries and those with press services not fully developed felt that financial support from government was often necessary to assure an adequate flow of information, and that such support should be recognized as a public responsibility. Some also feared that the freedom enjoyed by correspondents from countries with highly developed information media might not always serve their best national interests, either in the view presented to the outside world or in the local repercussions of such reporters' stories. They recognized the world press as the vital avenue to world opinion and welcomed the chance to be heard; but they were also distrustful of the light in which they might be made to appear. This widespread attitude was expressed in Kwame Nkrumah's response to foreign reporters when he was elected to office in 1951 while still in prison: 'I promptly refused to have anything to do with them for I had long since discovered that such people rarely report you verbatim; they give their own interpretations, and the more lurid and sensational they can make these, the better they like it.'*

It was not clear whether the trends of this period in fact enlarged or diminished the freedom with which news and other information circulated through the world. Certainly the volume of such news and information increased enormously. With every expansion in facilities the volume of communication expanded. One measure of such growth was the fact that Reuter's news agency was sending out fifty-four times as many words of news per month at mid-century as it did before the second world war.

Although there had been few restrictions on travel and communication in the years before the first world war, the area within which information then flowed freely was actually limited to the industrially developed countries and to certain segments of the population. The views which found expression and coloured the most factual of reports were those of the representatives of the European and American powers, and of the prominent members of these societies. In the following years the scope of news coverage broadened tremendously, newsmen sought their stories in all areas and walks of life and voices that had been entirely unheard and places and people which were virtually unknown beyond their borders became familiar to all who read or heard the news.

Against this broadening of the scope and spread in the dissemination of news, however, must be set the barriers which came into being as a result of the world wars and the establishment of rigidly controlling states—

* Kwame Nkrumah, *Ghana, the Autobiography of Kwame Nkrumah* (Thomas Nelson & Sons, New York, 1957), p. 134

censorship, passport and visa requirements, exclusion or suppression of publications, limitation of radio licences and jamming of radio reception. The record of news censorship maintained by the Associated Press showed that many countries censored or controlled news at the source, and that a number each year suppressed or suspended domestic newspapers, banned foreign papers or barred foreign correspondents. In the years after the second world war the record showed no clear trend, as the relaxation of censorship in one country was often balanced by a tightening elsewhere.

V. OPERATION AND REGULATION OF RADIO AND TELEVISION

By the nature of the medium, radio and television transmission required control, for the air waves are limited and the uncontrolled emission of messages on whatever wave the sender might choose could only produce interference and complete chaos. The principles of freedom of the press which had grown up with the unregulated private development of newspapers were therefore more difficult to apply to the air. As soon as radio passed beyond the stage of experimental and amateur sending and was used for general broadcasts, all governments took some steps to regulate its use.

The first problem was a technical one—non-conflicting use of the several air channels. In 1903, only four years after Marconi's first successful over-water transmission, an international radiotelegraph conference met on the invitation of the German government to establish conditions for intercommunication among ships of different nationalities and between ships and shore installations. The convention drafted at that conference was signed three years later by representatives of twenty-seven countries. At the Washington radio conference in 1927 a comprehensive frequency allocation table was drawn up, and a list was compiled for the Madrid conference five years later showing for each frequency the date on which the International Telecommunications Union had received notice of its use, in order to determine priorities. When the International Telecommunications Union became a specialized agency of the United Nations in 1947 it established an International Frequency Registration Board with headquarters in Geneva. All major countries set up national systems of regulation which made it possible for the international conventions to be carried out.

With respect to the material sent out over the air, the radio and television systems of the world fell into two main groups, those conducted as commercial enterprises and those operated as public or semi-public agencies.

The foreign broadcasts of all countries were supported and controlled directly by the government. For domestic broadcasts the commercial type of system prevailed in the USA and in most of the Latin American countries, while the public type characterized the systems of Europe, the USSR and much of the rest of the world; in the countries of the British Commonwealth, both private and public systems frequently existed side by side. In some

European countries the physical facilities were maintained as part of the state-operated post and telegraph system while the programming was carried on by one or more independent or semi-independent bodies. Technical features as well as policy tended to preclude a competitive pattern within these countries, for the multiplicity of political subdivisions, and the nearness of centres of population to each other required more limitation on the number of stations than was necessary in the large spaces of the US, Canada, Australia, the USSR or the countries of South America.

Some 97 per cent of United States radio and television stations were privately owned and received their entire revenue from advertising, excepting only a few stations used exclusively for educational purposes or operated by municipalities. They operated under licence from the government, which allocated the wavelength, authorized the strength and time of day of the transmission, required a minimum amount of broadcasting, obliged the station to provide a certain proportion of public service features without commercial sponsorship, and stipulated that if time were offered or provided to a political party or candidate equal time must be provided to opponents.

This system resulted in as many as 20 stations operating in some large cities. More than 3,000 radio and 400 television stations held licences for commercial broadcasting in 1955. On the principle that the public interest would be best served by maintaining competition, the number of stations which could be owned by the same company within a given area was limited, and although a large number of stations were linked to one or another of four nation-wide networks, local stations retained their autonomy and used only such network programmes as they chose. Programmes tended to be geared to popular taste, for the ability of the station to secure commercial sponsors and thereby to finance its programmes depended on the size of its listening audience.

A large proportion of radio and television time was devoted to advertising, which became a form of entertainment itself in order to hold the attention of the listener or viewer. Under this system the content of programmes and the rates charged to advertisers were not subject to regulation, beyond the limitations imposed by the general laws against libel and obscenity and the requirement of equal time for the presenting of opposing political views.

The most systematically and extensively developed of the semi-public agencies was the British Broadcasting Corporation, which served as an example, if not a direct model, for systems in a number of other countries. In its first form the BBC was a commercial company, formed at the suggestion of the Postmaster-General who asked the several private companies which had applied for licences to combine in a single organization. The shares of the company were held by manufacturers of radio sets and revenue was provided from taxes on the sale of receiving sets collected by the Post Office and turned over in part to the company.

When this source of funds proved inadequate, two parliamentary com-

mittees studied the problem and reached the conclusion that the state should exercise a closer degree of supervision over broadcasting because of its importance in political education and cultural exchanges and its influence on public opinion. While they did not favour a radio system directly operated by the state, they considered the system of free enterprise unsuitable because 'no company or body constituted on trade lines for the profit, direct or indirect, of those composing it can be regarded as adequate in view of the broader considerations now beginning to emerge'.* They therefore recommended a public corporation under the control of the Postmaster-General but enjoying the fullest possible liberty within limits clearly defined by royal charter.

The British Broadcasting Corporation operated on this basis from 1927 on, subject to review by Parliament at the time of the periodical renewals of its charter. It enjoyed a monopoly of radio broadcasting in Great Britain, receiving its support from an annual licence tax on all radio receiving sets in the country and allowing no advertising. It was fully responsible for its domestic programmes, except for the requirement that it broadcast summaries of parliamentary debates and communications from the government, with the privilege of announcing that such communications were broadcast by request of the governmental department concerned.

Under this system, and a variety of somewhat similar arrangements adopted by other European countries, the body which enjoyed a broadcasting monopoly was in a position to serve as an independent educational and cultural agency, under the overall supervision of the government. It was less dependent on public taste and under less pressure to provide entertainment than the commercially operated systems and was in a position to offer programmes geared to the tastes of different audiences instead of constantly seeking the maximum number of listeners.

State radio systems operated directly by the ministry of education or information and supported out of the public budget were general in the USSR, other communist countries and a number of Asian countries. In these systems the radio was used primarily for educational or propaganda purposes directly in line with the policies of the government.

Under all systems of regulation or administration, radio and television served a variety of purposes: the transmission of news, education, political propaganda, entertainment. Where they were commercially operated, they also were a major factor in creating and maintaining the mass market. The amount of time devoted to each purpose, however, varied with the type of broadcasting system.

The state-operated systems of the communist countries devoted most of the time to educational and scientific programmes, to official news and talks, relays of programmes from theatres and concert halls, and special courses of instruction for schools, farmers and industrial workers.

* Quoted in *Legislation for Press, Film and Radio* (Unesco, Paris, 1961), p. 158.

The French radio monopoly broadcast chiefly music and drama, in three programmes geared to different levels of taste. The BBC offered three distinct types of programmes designed to provide information, education and entertainment for audiences at different educational levels. American programmes, dictated by public taste and the desire of advertisers to attract large audiences, were primarily for entertainment.

All broadcasting systems devoted a substantial part of their time to news, which they generally secured from the same sources as the local press, i.e. the major wire services serving their areas. A few of the larger broadcasting systems—the principal American networks, the BBC, and others to a more limited extent—had their own correspondents in the major centres at home and abroad, and these constituted independent links in the gathering and dissemination of news.

VI. COMMUNICATIONS RESEARCH AND THEORY

The great importance of communications to all aspects of modern life led to study of the nature of communication, in its technical and psychological aspects, and to the development of a body of communications theory. At the technical level this involved such problems as the proportion of the sound waves set up by a voice which must be carried to the receiver for the quality of the voice to be conveyed, or the number of pictures per second required to give the appearance of smooth motion to the human eye. The information which a wire or radio circuit was called on to transmit was translated mathematically into common units so that the relative performance of different systems could be analysed in quantitative terms.

In the psychological area, studies of the number of items which a listener or viewer could grasp in a given period indicated that the capacity of the communications media to transmit oral messages or visual images exceeded the capacity of the listener or viewer to grasp what could be presented to him. Studies of the relative effectiveness of different media in communicating the same material to comparable groups of persons indicated that television could be more effective than either radio or printed page. Other studies investigated the kinds of stimulus which must reach the recipient in order to arrest his attention and to stand out from the background impressions of sight or sound or thought which he was constantly receiving. They explored the relation of effective communication to the *Gestalt* in the mind of the listener, to his motivation in receiving the message, and to the feedback of controls in response to signals already received which permitted or excluded further reception. Research in the technical and psychological areas contributed both to the technical efficiency of the media of communication and to their skilled use for purposes of education, administration, advertising, propaganda and entertainment, as well as for the transmission of information.

As the speed and complexity of modern life created demands for ever

more rapid and complex communication, systems that exchanged and acted on information without human intervention began to perform a number of functions.

Most of the technical work in the field of communications up to the middle of the century was posited on the need to communicate to the human ear or eye—sounds to hear, pictures to see, print to read. At mid-century many of the principles and devices which had been developed with these objectives were being applied to communication between machines. The technical problems were essentially similar—to convert a message into a form which could be transmitted and to reconvert it at the receiving end into a form in which it conveyed the desired information to the receiver, whether in the same form that it went in or in some other form.

The most advanced development of automatic communication was in the military field, in such systems as those by which a missile seeking a target was spotted by radar which ordered up an interceptor, the missile dodged and the interceptor pursued—all under instructions from automatic communications devices. As the air became filled with jet planes travelling at or near supersonic speeds, pilots could not depend on their eyes and reactions to see and avoid an approaching plane even in a clear sky. By the late 1950s technical means were at hand to replace the observation and guidance of human pilot or ground control, by non-human observation, computation of courses and automatic instructions to automatic control devices on planes. Electronic brains to detect and direct planes in relation to each other were beginning to be used in military air protection systems, and were in prospect for general air traffic control as a necessary form of automation to avoid disaster in the air.

While these elaborate systems of non-human communication were only beginning to be used, or were available but not actually in operation, many less spectacular forms of non-human communication had become part of everyday life. Automatic telephone service took a dialled number, converted it into a hunting mechanism to find a series of open circuits until it located the desired number, reported back if the number was busy, and on long-distance calls informed an accounting machine that a call had come from the initiating number to the point of destination, and instructed the accounting machine to enter the correct charge to the correct account. An air-line clerk could determine immediately whether there was space on a given flight by inserting a card in a machine and receiving an automatic report from the central recording machine many miles away that all space was booked or that the flight was open. In the field of communication the age of the mechanical robot was already at hand.

VII. COMMUNICATIONS IN MODERN LIFE

The importance of communication as a factor in modern life could hardly be overestimated. Modern man found himself bombarded with information

and impressions, constant, immediate, insistent and beyond his direct experience, which broke into his private world and made him part of a larger scene. Communication ran ahead of direct experience, constantly arousing new desires and new images. Mass communication played an incalculable part in giving to the peoples of the formerly isolated regions of the world the stimulus to seek social and political change, whether the ideas came by way of the radio, a motion picture or telegraphed news in the popular press.

The new media of communication gave power to new people—to the man in the village who could counter the authority of the headman with the authority of what he had heard over the air, or to the government or other agency which controlled the media and could use them as tools. It was natural that every revolutionary group after the 1920s should have made the radio station one of its first objectives.

Radio and television made it possible for central governments to communicate instantly with the remotest areas, to keep all parts of the nation fully informed and acting in concert and to evoke immediate response by telephone or telegraph to mass appeals from leaders. The ability of the Chinese leadership to communicate each new slogan or appeal for action to the entire vast country by radio contributed in no small measure to the extraordinary speed with which radical changes were introduced; the use of the television by the Cuban revolutionary leader, Fidel Castro, in 1959, brought such immediate nation-wide response that he was able to force the president of the republic to announce his resignation while the leader's same all-night television broadcast was still going on.

Through the media of mass communication, entertainment, knowledge, music and drama reached people by the millions with material which had been enjoyed only by hundreds or at most thousands of people in the past. They provided the means for the spread of the mass culture which replaced both the folk culture and the mass ignorance which had characterized large segments of the world's population. The quality of this culture was a matter of debate, but the role of the new media of communication in its creation and spread was beyond dispute. Together with mass production and mass transport, mass communication set the tone of twentieth-century life.

CHAPTER XII

MEANS OF DESTRUCTION

THE application of scientific knowledge to the means of destruction during the first half of the twentieth century radically changed the character of warfare and created threats to the very survival of mankind. In a succession of stages it transformed warfare from the specialized activity of a limited military group, first into the total mobilization of industrial resources to produce weapons which would overwhelm military objectives, then into the total involvement of entire industrial societies in the process of hurling concentrated, mechanized force against military or civilian targets anywhere on the globe, and finally into a scientific contest to develop weapons of annihilation and the means of delivering them to destroy the opponent's total society. At each stage the forces of destruction were increased many times, the complexity of organization was very greatly enhanced, the moral and political stability of the home front as well as the armed forces became a more critical factor, and dependence on scientific development became more complete.

I. METHODS OF WARFARE AT OPENING OF CENTURY

By the opening of the century weapons designed by the application of scientific technology had already given the industrialized nations an overwhelming advantage against the non-industrialized peoples and had provided a basis for the political and economic imperialism of the western powers. The machine-gun had given the unskilled foot soldier a formidable weapon and had stepped up the destructive power of a given fighting force. Navies were composed of armoured vessels and the development of new steels had strengthened the armour plating of battleships and increased the piercing power of naval guns. The submarine had made its appearance to challenge the surface vessel, using internal combustion for surface propulsion and electric power for sub-surface motion. Field artillery had attained considerable range and accuracy, firing fragmentation shells in place of the old cannon balls which only did damage if they hit their mark directly.

Although chemical warfare had not been employed, it seemed apparent that the rapid developments in chemistry in the last half of the nineteenth century would sooner or later find their way into weapons. It was clear too that, once flight became practicable, its potentialities were as great for military as for civilian use.

All these developments of technological warfare made it evident by the beginning of the twentieth century that a new era of destructiveness was at

hand unless means could be found to curb the process of applying scientific technology to weapons of war or to restrain the use of such weapons.

In the first Hague Peace Conference in 1899 the powers there assembled attempted to prevent the application of chemistry and aviation to warfare declaring prohibitions on the launching of projectiles from balloons or by other similar new methods and on the use of projectiles to diffuse asphyxiating or deleterious gases. Efforts to limit the development and quantity of arms failed, however, and the second Hague Peace Conference in 1907 concentrated its effort on establishing substitutes for war as the means of settling international disputes, and on an elaboration of the rules for 'civilized' warfare designed to take account of the situations created by the new military technology.

Although new destructiveness was envisioned at the opening of the century, the revolution in warfare that was to effect a revolution in life was not foreseen.[1] Nor did warfare occupy the central position that it came to fill in the following years. Military activity was carried on by a limited group of military personnel in a limited geographical area, while civilian life remained relatively undisturbed. Force was accepted and employed as an instrument of national policy, and had been in virtually continuous use during the nineteenth century in brief local conflicts involving the maintenance, extension or clash of colonial authority, the unification of Italy and Germany, the fate of the Ottoman empire, Japan's bid for status as a first-class power, accessions to political power in Latin American countries, and conflicts between European powers that came to a head in the Crimean and Franco-Prussian wars. But only the American Civil War, by its intensity and scale and its utilization of new industrial means, had presaged the kind of warfare which was to mobilize total resources and involve whole peoples.[2] Few people at the opening of the century saw that the application of modern science and technology to warfare would within fifty years so increase man's power of destruction and disruption that it would threaten the survival of civilization and indeed of mankind itself.

In fact, in spite of the continuous presence of warfare during the nineteenth century and its use to effect a major shift in the relations among nations through the victory of Japan over China and Russia, there was a general tendency in the western world to regard warfare as an obsolete instrument, to assume that the world was entering a period in which war would play a lesser part while economic expansion held the centre of the stage, and to relegate military activity to a specialized corner. It was assumed, furthermore, that if war should, nevertheless, break out it would be carried on according to more 'civilized' rules. The two Hague conferences were an expression of the latter concept.

Yet at the same time world tensions were mounting and technical developments were making localization and regulation of the conduct of warfare less likely or possible.

In the face of efforts to establish means to settle international disputes

without violence, notably the creation of the International Court of Arbitration at The Hague in 1907, the major powers engaged in an armaments race which further contributed to the rising tension. In this race the private armaments industry was the main source of new developments in military technology. Working to expand their markets and enhance their sales, the great armaments firms—Krupp in Germany, Vickers-Armstrong in Britain, Schneider-Creusot in France, Skoda in Austria and Putiloff in Russia—not only vied with each other in the design of weapons that would out-fire those of their competitors but increased their own sales whenever they could make obsolete one of their own products.

The armaments race took the form chiefly of adding weapons of improved design to the arsenals of each country, guns of greater velocity, naval craft with greater or more accurate fire-power or more armour or speed. These weapons were not expected to modify in any major way either strategy or tactics, much less to change the nature of warfare almost completely. They were simply fitted into the prevailing concepts of warfare—i.e. a vigorous attack on enemy forces with the forces at hand, defence or counter-offence, and a quick decision on the field of battle.

Although the armour of fighting forces had been vastly altered since the days of Napoleon and Lord Nelson, essential military concepts had changed little. The leading authorities on naval warfare, Admiral Mahan and Sir Julian Corbett, reached the conclusion that the ironclad steamship with heavy fire-power had not significantly altered naval warfare and that the lessons of the wars of the sailing ships still held good, though some other authorities held that such new types of weapons as torpedoes, mines and submarines had changed the character of war at sea. On land, railway and telegraph had merely expanded the field of strategy while modern rifles and artillery had intensified the tactical problems of defence, and conscription had increased the size of the forces involved. The enemy forces remained the sole target; even munitions plants were not deemed by the strategists to be military objectives. The potentiality of the aeroplane and of chemical warfare had been recognized, but the prohibitions laid down by the Hague Conference were expected to preclude their use.[3]

II. FIRST WORLD WAR: BEGINNING OF TOTAL WAR

The first world war drastically changed the nature of warfare. Within a few weeks the war settled into positional warfare in the trenches. The improved weapons—quick-firing field artillery, rifles and machine-guns—pinned down the enemy's forces and gave fire-power almost complete superiority over movement. The difficulties of supplying and directing the unprecedentedly large forces in the field contributed to the immobility. Traditional military skill was reduced to ineffectiveness.

The unexpected stalemate precipitated a general revolution in warfare which had been implicit in the development of modern industry. In place of

the traditional clash of fighting forces, warfare became a clash of national resources. The traditional limited and marginal war efforts which drew on only a fragment of the nation's manpower and resources were replaced by the total mobilization of manpower and industrial potential. The new situation brought the new concept, 'total war'.[4]

In the effort to build up a sufficient concentration of forces to break the long, consolidated fronts in continuous contact with each other, belligerents mobilized their men to the utmost and some of their women. In order to meet the abrupt and unforeseen rise in the requirements for munitions, they were driven to expand their war production from a few specialized firms until they were mobilizing their full industrial and agricultural capacities. The military demand for manpower, colliding with the equally urgent demands for workers to produce munitions and to meet the minimum needs of civilian life, required a continuous, complex process of adjustment. Economic systems geared to peacetime competition had to be organized and co-ordinated for the common effort and measures had to be taken to prevent inflation. Emergency administrations with tens of thousands of staff workers had to be built up.

Total mobilization, furthermore, aroused and depended upon a sense of personal involvement throughout all classes and groups in the populations of the warring nations. Rationing made involvement general, while new mass media of communication and means of propaganda were used to whip up emotional identification. The civilian populations ceased to be bystanders; they became 'home fronts' backing up the fighting fronts.

The effort to break the stalemate by overwhelming the opponent with the sheer weight of military equipment was concentrated on relatively few items. Thousands of millions of rounds of ammunition for small arms were turned out, hundreds of millions of artillery shells, millions of rifles, hundreds of thousands of machine-guns and tens of thousands of pieces of field artillery. There were thousands of millions of sandbags and thousands of miles of barbed wire.

While these established items were being produced on a mass scale, new technical developments brought poison gas, the tank and the beginning use of the aeroplane.

The use of poison gas, which the Hague conventions had failed to forestall, seemed even more ominous than the growing intensity of fire-power in pointing to the possibility that the destructive potentials of modern technology might outrun the possibilities for protection. The tank was a direct product of the breakdown of the war of movement, and met the need for an armoured device which would enable men to get out of the trenches and stand up to machine-gun fire. Conceived by the British when the war was already in progress, the first tanks reached the battlefield two years after the start of the conflict. By the close of the war, the tank had become a major new offensive weapon for the Germans, but was still of secondary importance for the Allies.

Although a military potential had been envisaged for the aeroplane from the time of its invention, its use in the first world war was confined almost entirely to reconnaissance, including observations to help direct artillery fire, and fighter cover for observation planes. Raids on England by the obsolete and highly vulnerable Zeppelins had nuisance value rather than strategic importance. Toward the close of the war, the possibilities of using planes for bombing were just beginning to be explored. There was however no serious attempt to destroy the productive capacities of the enemy.

Compared with the most elaborate previous military operations, the new industrial-scientific warfare was extremely complex. The continuous front lines constituted immense networks of field fortifications, barbed-wire obstacles, observation posts, systems of communication, approach and supply. Here the men on the ground—infantry, engineers, artillerymen—struggled against the preponderance of material, of which the key elements were the machine-gun, field-gun and tank, supplemented by a whole arsenal of newly developed specialized weapons—hand grenades, trench mortars, steel helmets, barbed-wire cutters etc. Massed artillery, as many as 100–150 guns per mile, equipped with new scientific devices for spotting, ranging and co-ordination of fire, hammered enemy positions to shreds. Volume increased from half a million shells per day to one and finally to two million. The vast array was co-ordinated in gigantic, closely integrated and synchronized attack plans for a decisive strategic breakthrough which repeatedly failed because the very complexity resulted in some hitch which prevented the full exploitation of a break when it was opened up.[5]

The revolution in land warfare was not paralleled on the sea, for the traditional strategy of blockade remained essentially unchanged and, though the new mass-production methods of industrial mobilization could speed up the flow of minor weapons—guns, mines, depth-charges—they could not be applied to the supply of fighting ships. The effect of the sea warfare, however, was to increase the intensity and completeness of total war by the extent to which the blockade and counterblockade cut into the lives of the civilian population. Aware that military effectiveness now depended on the functioning of the industrial economies, both sides treated virtually everything as contraband and used blockade and counterblockade to starve industry of its raw materials and civilian populations of food and other necessities. Where this meant unrestricted submarine attack against merchant shipping, the fate of crews and passengers whom the submarine was in no position to rescue drove home dramatically the total character of the conflict. The fate of these civilians sharply foreshadowed the more complete total war in which civilian populations themselves, as well as armed forces and military installations, were to become major military targets.[6]

III. DEVELOPMENT OF MILITARY TECHNOLOGY

After the cessation of the first world war hostilities, the development of military technology slowed down in the face of rapid demobilization, a general revulsion against warfare as too destructive to be tolerable, the effort to prevent further resort to war through the formation of the League of Nations, and the direct attempt to check the naval arms race by the Washington Naval Conference of 1921. Nevertheless, the military establishments proceeded to digest what they had learned during the war and to improve both the new weapons and the new organization which the war had brought forth.

Industrial organization was most thoroughly assimilated. The military themselves took on many of the features of modern industrial society,* and each country formulated industrial mobilization plans, either as part of general economic planning, as in the Soviet Union, or as special industrial mobilization schemes devised by the military in unplanned economies, as in the United States.

The development of weapons proceeded more conservatively, and involved chiefly improved performance of existing types—increased rapidity of rifle and machine-gun fire, new methods of automatic direction and computation in naval and aircraft artillery, speedy and reliable tanks, submarines able to dive faster and deeper and to range farther, new types of torpedoes and mines and new aircraft, especially those able to operate over sea from land or carrier bases. But science was not as yet regarded as a field to be systematically explored for possible military application. The outstanding development, radar, which radically changed the strategy of sea and air warfare, was accepted by the military only after civilian scientists had repeatedly demonstrated its reliability and significance, although its sea counterpart, loran, was discovered by naval research scientists seeking to find a means of detecting submarines.

New and improved devices and weapons were fitted into the framework of strategy and tactics, but the process was still incomplete when the second world war broke out. Military transport was motorized, although the railways remained the most important means of moving large numbers of troops and supplies over land. Radio, together with improved long-distance telephone, extended the range of communications and permitted the tactical direction and co-ordination of forces, including tanks, planes and submarines. Once the stubborn opposition to tanks in most armies was overcome, the slow, almost blind tanks used individually in the first world war were transformed into powerful, concentrated forces by the development of systems for communication, control, fuelling and repair. The major use of planes by both sea and land forces was evolved in the face of resistance from the more conventionally minded military leaders and air defences were developed.

Although each aspect of the new mechanized warfare was worked out, the whole system of warfare was not reformulated in the light of the radical

* For the development of military institutions, see Chapter XXIV.

revolution which had taken place. The majority of military opinion envisaged warfare as a repetition of the 1914–18 deadlock which would be gradually overcome by the weight of material, and they directed their plans toward a maximum of forces.[7] A minority thought in terms of avoiding or overcoming deadlock by the use of small, concentrated, highly equipped and swift units. The developments of the inter-war years constituted a bundle of loosely co-ordinated, separate efforts. They were to experience as revolutionary a change in the course of the second world war as had the earlier system during the first.

IV. GLOBAL CONFLICT: SECOND WORLD WAR

The second world war was both global and total in a much more complete sense than the war of 1914–18. In this it reflected both those technical developments, including radio, radar and carrier-based and long-range planes, which immensely extended the range over which operations could be stretched, and the greatly increased ability of industrial societies to co-ordinate the use of their resources.

Whereas the technological developments of the first world war had made the defence almost impregnable until finally overwhelmed by sheer weight, the attack gained ascendancy in the second world war through more powerful weapons, more effective methods of direction and supply and greater mobility which made possible a virtually irresistible concentration of effort. The grand strategy of the second world war was to concentrate forces and supplies at any point on the world-wide theatre of operation.

At sea—and in its broadest dimension the second world war depended on control of the main lines of sea communication—this involved the greatly increased reach of naval forces through the use of air reconnaissance, radar and the aircraft carrier. The last replaced the battleship as the key naval vessel. Submarine warfare was carried on by ships that were no longer isolated attackers confined to coastal waters but centrally directed packs capable of roaming the seas and concentrating on targets as soon as they were sighted. In turn, the submarines were spotted and hunted down by air reconnaissance and special hunting groups.

On land the industrialized spearheads composed of tanks, motorized or airborne troops or tactical air forces used *blitzkrieg* tactics to break through at critical points and then, with vastly superior speed and range, to roll up entire opposing fronts manned by troop units many times the size of the attacking force. Where these tactics failed, it was at first largely because of breakdown in the supporting operations of repair or supply; later, defence in depth and fields of land-mines, together with massed artillery and defensive tank forces, provided a more mechanized version of the barbed wire and armoured defences of the first world war.

Air-power played a vital role, not only as a support to the older forms of

warfare but as an independent force. It was not, however, decisive. Up to the last phase of the war its range was limited and its employment diffuse. In the course of the war the bomber range was extended from 500 to 1,500 miles and the value of the sharpest possible concentration of effort on crucial objectives was gradually recognized. But it was only in the final stages of the war that life in the countries which suffered the most severe aerial bombardment, Germany and Japan, was decisively disrupted; throughout most of the war industrial mobilization in all the warring countries proceeded with relatively little disorganization.

The character of industrial mobilization also changed markedly during the second world war. Instead of the mass production of a few key items, as in the first world war, the second conflict drew on virtually every phase of industry. The new engines of war—tanks, planes, radar equipment, bomb-sights etc.—were highly complex and delicate. War production involved an elaborate system for the mass production of several million items according to schedules and priorities that constantly shifted to incorporate new technical developments and the changing emphases of the war strategy. This was most strikingly evident in the United States, whose rate of munitions output by the end of the war equalled the combined production of both its allies and its enemies.

The tremendous output and the ability to meet changing requirements, such as the critical need for synthetic rubber, depended upon the organization and co-ordination of the whole industrial system through which mass-production methods were applied to the most complex instruments of war. At the opening of the war, for example, the United States had only a few hundred skilled lens grinders, but hundreds of thousands of bomb-sights and other optical instruments were needed. In a short time this highly skilled operation had been analysed into component elements each of which could be quickly learned, the few skilled men were assigned to inspection, instruction or final finishing, and bomb-sights or other instruments were rolling out by the thousand each day. At the opening of the war aircraft were virtually built to order. Very soon they were coming off the assembly lines along with mass-produced cars, lorries and tanks.

Most significantly of all, not merely technology and industrial organization but science itself was mobilized to contribute to the war effort. The most intense concentration of scientific work was directed both in Germany and among the Allies at developing the atom bomb, whose possibility had been glimpsed on the eve of the war with the first report in 1938 of the successful fission of the uranium atom. The final achievement of the bomb represented one of the largest and most highly focused scientific enterprises ever undertaken for any purpose.

Although the size and significance of the atomic project overshadowed all other scientific efforts, many of the latter were of major importance. In the young field of electronics the development of the magnetron permitting the

advance from metre to centimetre radar was possibly decisive in combating the submarine, and the proximity fuse which was detonated on approaching its target revolutionized air combat and brought decisive air victories before the German forces knew what had hit them. The application of jet and rocket principles to planes and long-range missiles began to make anti-aircraft defences obsolete.

Secret research in the fields of chemical and biological warfare by all sides prepared for defence and retaliation if the enemy should use one or the other of these means. Much of this work remained unknown, as neither side ventured to let loose these potentials.

Medical research made possible rapid strides in the treatment of wounds, especially through the use of blood plasma, sulpha drugs and penicillin, with the result that, for example, the proportion of United States soldiers treated for wounds who died was reduced to half that of the first world war. Improvements in immunization and treatment of disease reduced mortality from other causes. The social as well as the physical and biological sciences were also enlisted as their knowledge of human behaviour was applied to the conduct of psychological warfare and the maintenance of national morale.

The second world war was a far more total war than its predecessor also in the involvement of the civilian population. In addition to the fuller incorporation of industry and science into war production and the greater regimentation of life through rationing, price and wage controls and the direction of labour, mass bombings, mass occupation of territory and the uprooting and displacement of millions of people all but obliterated the distinction between military and civilian fronts. Whereas in the first world war a division, sometimes bitter, had continued to exist between those who fought and those who remained at home, the man at the front in the later conflict often felt that he was as safe as, or safer than, his family exposed to a rain of bombs.

As the war progressed, saturation bombing became a major objective. The scientific race to develop an atomic bomb was not primarily for use against military personnel or equipment but against the nerve centres of the enemy's economy and, inevitably, the concentrations of population. The two atomic bombs, dropped at the close of the war on the Japanese centres of Hiroshima and Nagasaki, showed the total society to be now not simply the support for military instruments and an adjunct to military objectives but the central military objective itself.[8]

V. WARFARE OF SCIENCE AND PEOPLES: THE NUCLEAR AGE

The new nuclear weapons introduced an element so radical and decisive as to revolutionize all other aspects of warfare, and immensely to accelerate the pace of military development. Their destructive power was out of all proportion to anything known before. Bombs in the first world war averaged 50–100 lb; in the second they rose to the equivalent of 10 tons of T.N.T. The first

atomic bombs boosted the destructive power two thousand times to an estimated equivalent of 20,000 tons of T.N.T. Within ten years the thermonuclear bomb had multiplied destructiveness one thousand times more, to two million times the power of the biggest pre-atomic bombs of the second world war.

Even beyond the immediate destruction by which, for example, an average ten-megaton hydrogen bomb could sear the heart of a city with a fireball four miles in diameter, was the lethal or damaging effect of the radioactive fall-out of particles sucked up into the atmosphere by the explosion. While the extent of the fall-out would depend on a variety of factors, and the seriousness of the genetic as well as the immediate effect was not wholly determinable, the area officially reported as affected by the thermonuclear test of March 1, 1954, was 7,000 square miles. The direction of the wind and other atmospheric conditions would determine how far this fall-out would extend its lethal influence and on whom it would descend.

Means to deliver nuclear projectiles kept pace with the development of the weapons themselves. The range of bombers rose in a decade from about 1,500 miles at the close of the second world war to 5–6,000 miles, bringing the world's main centres of power and industrial production within reach of each other. Long-range intercontinental missiles were being developed. The struggle for air supremacy became a struggle for the chance of survival.

In this nuclear phase of the twentieth-century revolution in warfare, scientific advance and the total organization of the life of the nations were the central elements. Military preparedness for total war virtually took the form of scientific development as countries or groups of countries sought to build up such superiority in weapons and means of delivery as to act as a deterrent against the use of these ultimate destroyers. The home fronts became principal fighting fronts, with cities, industrial centres and transport bottlenecks as major military targets and their survival a prime defence consideration and the indispensable basis for any effective retaliation.

For defence and survival, gigantic continent-wide networks of radar chains for early warning were constructed across the frozen Arctic and far out to sea. Elaborate systems of interception, relying increasingly on missiles with guidance or homing devices, were set up. Interception, however, needed to be virtually 100 per cent effective to provide protection against nuclear weapons, and the difficulties of intercepting missiles were very great.

Measures were taken in many countries to reorganize peacetime life against the threat of nuclear destruction and to establish emergency organizations for civil defence, more elaborate and flexible than those which functioned during the second world war. In countries dependent on sea-borne supplies like Great Britain, many small subsidiary ports were made ready in case main ports should be paralysed. The city of Stockholm prepared to carry on its life underground in shelters hewn out of the granite foundations. Government offices and business firms in a number of countries established alternative

headquarters, set up succession lists of officials and executives, and microfilmed and stored vital documents. Industrial mobilization plans were geared to substitutions and dispersal in case of disruption.

As ever swifter and more exacting weapons were produced, they placed new demands on the human beings who had to operate them. Science was also called on to determine the limits of human endurance and capacity to function under extremes of speed, heat, cold, altitude, pressure, sudden change and exposure to radiation.

In the decade following the second world war, the struggle for superiority in destructive weapons and means of delivering and intercepting them virtually constituted in itself a form of warfare. The intensity of the struggle, the size of the effort, and the extent of actual or potential involvement was greater than during the hostilities of the first world war and approached in everything except active destruction the situation during the second. The threat was far greater. Although it was recognized on all sides that all-out nuclear warfare could only result in making much of the globe uninhabitable, the struggle went on to build up more and more strength in order to prevent an opponent from securing a decisive advantage in striking power or defences.

Central to the new contest was the quest for speed and for the means of detection which would prevent surprise. It was military aircraft that broke the sound barrier and went on to higher and higher speed records. Long-distance missiles were still faster and were designed to travel from one continent to another in a matter of minutes.

Against such speeds, observation posts located within national boundaries, or even in the reaches of the Arctic or the oceans, could hardly provide effective warning of a surprise blow. It therefore became necessary to seek means to bring and keep within view as large a segment of the globe as possible, including distant parts of the territories of potential opponents, in the hope of detecting in advance dangerous concentrations indicating the threat of aggression. Both manned and unmanned rocket devices containing radar and television equipment were designed to observe from high altitudes.

The next step was observation from space. The USSR and the United States placed earth satellites in orbit around the earth, equipped with instruments for various types of observation in connection with the International Geophysical Year, 1957–58. Though these earth satellites were designed for other than military purposes, much of the impetus to their development came from the military-scientific contest to which the revolution in warfare had brought the world by the middle of the twentieth century. Their possible contributions to military technology were well recognized.

While warfare was developing into a potential for unlimited destruction, the continued use of force in limited but intense struggles led to other developments. In an effort to devise military instruments which would be usable and not merely deterrents, nuclear weapons were reduced in size to the point where they could be considered tactical weapons, though still immensely destructive

While the powers engaged in the race for supremacy in the capacity to inflict or resist annihilation, they also began to equip their armies with atomic artillery and to seek means of defence against relatively small-scale but inevitably devastating atomic attack.

In the remaining outposts of empire where colonial peoples resisted continued authority or in situations with the character of civil wars, as during the prolonged struggles in Indo-China and Algeria, weapons of massive destruction could not be used. Modern weapons did not equip armies to cope with guerrilla tactics.

The changed character of warfare was not solely the result of the changing technology of war. It was in part the expression of the changed character of the state. While total war was tending to make the state more total, the inclusive state was making war into an expression of the whole people.

As a total national effort, whether on the part of a democratic or an authoritarian state, war had to be pursued for complete victory and to inflict utter defeat. The psychology for total war was created by systematic whipping-up of hatred between nations. By the use of powerful devices for the control of opinion, the enemy was shown as wicked, inhuman, the destroyer of civilization—while each side saw itself as fighting in the cause of humanity, to safeguard civilization, to save a way of life.

War having thus been elevated to a struggle between light and darkness, compromise became difficult from the beginning and unconditional surrender with a dictated peace the unavoidable objective. The defeated enemy, moreover, was made to bear the burden of guilt as well as defeat. The war crimes trials in Germany and Japan which followed the second world war were a new phenomenon. At the close of the first world war the popular demand that the German Kaiser be tried for war guilt failed to find support among the governments of most of the victors; but after the second world war not only generals but diplomats, statesmen and others who had executed the national policy of their governments were tried before a court composed of their enemies.

The corollary of defining the struggle in terms of civilization and its opposite was to arouse in the victors a sense of responsibility for remaking the world and especially for reforming and re-educating the former enemy. The object of peace-making after the wars of the twentieth century was not, as in previous eras, to patch up the quarrels, transfer bits of territory and restore the system which had been shaken by war, but to reconstitute the world in the image of the victors. In the peace-making after the first world war both the traditional and the new attitudes were present, the representatives of the new forces seeking to reconstitute the world on the principle of self-determination of nations while representatives of the older view were more concerned with specific annexations and safeguards. The treaty structure which followed the war was an uneasy compromise between the ideas of reconstituting the world and the old policy of aggrandizing national interests.

After the second world war, the objective of remaking the world and re-

educating the vanquished was clearly dominant in the occupation policies of the victorious governments in Germany, Japan and eastern Europe, though the victors had two quite different images in terms of which they sought to reshape societies. Even the two minor wars of the mid-century, Korea and Indo-China, clearly demonstrated that modern war left no room for a peace settlement. At the close of each the only alternatives were division of the country or total submission of one side or the other to the way of life which the other sought to impose.

The impact of modern warfare on the life of mankind could hardly be exaggerated. Its terrible destructiveness was only the first aspect. The first world war was estimated to have cost the nations of Europe no less than 20,000,000 men, killed and disabled. The lost generation in Britain, France, Germany and Austria was a notable aspect of the inter-war years. In the second world war losses of military personnel alone amounted to one person in 22 of the population in the USSR, 25 in Germany, 46 in Japan, 150 in the UK and 200 in France and China. Civilian losses in some areas were much greater. Estimates of physical destruction could not be expressed in common units like lives; suffice it to recall that Japan's major cities were already gutted by bombs and fire before two of them were laid waste by atomic destruction, scorched earth tactics of retreating armies devastated western Russia, Burma and parts of China, saturation bombing and shelling left little but rubble in many parts of Germany, Italy, northern France and Britain, and broken dikes let the sea take over parts of Holland.

The indirect effects of total war were no less far-reaching. The nature of modern warfare tended to strengthen the large as against the small states, for only a major industrial nation could create and sustain a modern military establishment, and no small nation could stand against the forces of a large power. At the same time it became increasingly difficult for small nations, no matter where they were situated, to avoid involvement. With airlifts, neither Arctic ice nor desert sands offered the obstacles which they had in the past; the Canadian Arctic became a principal military frontier of North America. For long-range missiles there were no frontiers. However uninterested a small nation might be in a conflict among large powers, it might find itself at any moment in the path of the latter's military sweep. Military considerations thus tended to make small countries increasingly dependent on large, and to force countries together into blocs.

Modern warfare was no cheap game; it involved the entire financial resources of a state. Britain, the strongest financial power in the nineteenth century, was forced as a consequence of four years of the first world war not only to yield financial primacy to the United States but to repudiate her war debt. After the second world war it was only the huge financial resources of the USA through the Marshall Plan for aid in reconstruction that salvaged the economies of the European nations.

Modern war did much to determine the direction and shape of economic

activity, not only during actual war when the economies of the belligerent countries were directly organized and oriented toward the war effort, but in non-war years when the burden of armaments continued to be great. This was strikingly evident in the planned economy of the USSR, which from the start included in its development plans the creation and maintenance of its military potential, and whose long-range plan to establish industrial centres in Siberia was accelerated by the invasion of its western region in the second world war. But war had major repercussions also on the unplanned economies of other industrial countries as well. It acted as a tremendous stimulus to production, especially outside the areas of destruction, bringing a great industrial spurt in the USA, of moderate extent in the first world war and of major proportions in the second. Even the economies of continental Europe and Britain, which were disrupted by destruction and disorganization, were stimulated by war demands to adopt new technology and to devise new forms of organization.

Political effects were no less crucial. The tendency for the functions and authority of the state to expand, a broad trend of the twentieth century, was greatly increased, and the authority of those in control was strengthened. Under the actuality or threat of war, democratic governments extended their authority in ways contrary to their traditional methods and principles, forced by a sense of urgency to take measures which appeared to be necessary for survival. The actuality or danger of war offered to authoritarian states additional possibilities for strengthening state control over the population.

Thus modern war and its echoes tended to make all states more authoritarian and to exact a greater measure of conformity from their citizens, lest divergence from the nationally established path or challenge to the wisdom of those in authority give aid and comfort to the assumed enemy. The tendency to insist on conformity was less marked in countries where traditional institutions for registering dissent were strong—in Britain, for example, where the loyal opposition had long been part of the structure of government. It was stronger in countries such as Germany where the tradition of authority was strong, or the USSR where dissent had, historically, been expressed through revolution. But everywhere the direction of trend was the same.

The impact of modern warfare on social structures was immense. Though the bases for many or most of the social changes which occurred during the first half of the twentieth century were present in the societies where they took place, the shock of war played a major part in loosening custom and breaking down existing structures. The demands of war and the total involvement of peoples placed individuals and groups in new positions from which they did not entirely retreat when more normal conditions returned. Wartime experience changed the relationships of classes, altered the role of women and gave new opportunities to minority groups. Especially in countries where there was a diversity of peoples and customs, the armed forces tended to act as a force for national solidarity and social integration. The conscript army was an equalizer, and the increasingly technical requirements which had to be met by

military personnel resulted in the spread of a variety of types of knowledge through the population by the process of military training. As warfare became more scientific and science itself came to be part of the conflict, it raised the prestige of science in the public mind and emphasized scientific rather than humanistic education.

Finally, modern warfare entered the psychology of people, to distort their values. Historically, military virtues had always been associated with personal prowess and valour. Modern war left few opportunities for this type of conduct. When warfare meant not a contest of skill but the weight of destruction, it tended to dehumanize those who waged it—not merely the bomber whose target was a city full of people going about their daily life, but the total society, as it became inured to destruction, suffering and violence.

This effect may be seen in the changed attitude toward destruction between the two world wars. When the cathedral of Rheims suffered as a result of German bombardment during the first war, the moral conscience of the world was shocked. But in the second war, when the monastery of Monte Cassino was destroyed and the cathedrals at Cologne, Coventry, and many other churches and shrines suffered from air attack, the destruction was regarded as an unfortunate but necessary part of the total war. The climax was of course the atomic destruction of Hiroshima and Nagasaki. The exigencies of total war threatened all social values.

NOTES TO CHAPTER XII

1. Professor N. Talensky thinks it should be emphasized that although (as many leading sociologists agree) wars undoubtedly exert an influence upon the development of society, they have never occupied the central place in the society's life nor have they called forth the revolutionary changes in the people's mode of life.

2. It is incorrect to say, Gyula Raszszo writes, that only the American Civil War, by its intensity and scale and utilization of new industrial means, presaged modern warfare. In the Franco-Prussian war of 1870–71 the fighting was on just as great a scale, and modern military technology was employed just as widely, as in the American Civil War.

3. Gyula Raszszo points out that the account given of the military concepts prevalent at the beginning of the twentieth century is inaccurate. The authors devote too much attention to theories of naval strategy and overlook the revolutionary changes that took place in military science, one of which is connected with the name of Alfred von Schlieffen.

4. Professor N. Talensky thinks that at this point it is necessary to add that the essence of total war is the complete subordination of the whole life of the people and the economy of the belligerent state to the cause of preparing and waging war, with the application during the war of all possible means of terrorizing and destroying *en masse* the civilian population.

5. Gyula Raszszo writes that in general it is true to say that the strategy of the breakthrough failed, not because of its unparalleled 'complexity', but because there were not enough vehicles able to move at sufficient speed. After all, the second World War created conditions that were incomparably more complex, but during the course of the fighting there were quite a number of strategic breakthroughs: the point was that armies now possessed armament of adequate power and mobility.

6. Professor N. Talensky points out that during the first and second world wars the dominant principle was that the course and outcome of the war would be determined in the main by the destruction or annihilation of the armed forces of the enemy.
7. Gyula Raszszo writes that in his opinion it is incorrect to say that military opinion was for the most part conservative; this is true only with regard to French, British, and to a certain extent American military thinking. There can be no doubt that the requirements of modern military technology were completely taken into account by Soviet military science, and also in many respects by German and Italian military science (above all in the employment of tanks and aircraft).
8. Professor N. Talensky underlines that the dropping of the two atomic bombs on the Japanese cities of Hiroshima and Nagasaki was in no wise dictated by military necessity since the outcome of the war had by this time already been decided. See also: J. D. Bernal, *World Without War* (London, 1958); L. Pauling, *No More War* (N.Y., 1958).

SECTION THREE

DEVELOPMENT AND APPLICATION OF THE BIOLOGICAL SCIENCES

CHAPTER XIII

DEVELOPMENT OF THE BIOLOGICAL SCIENCES*

THE outward character of biology became greatly altered during the first half of the twentieth century, so that its emphases seemed to differ markedly from those of its nineteenth-century counterpart; its fundamental concepts were less changed than might appear.

Evolution was the dominating concept in biology at the end of the nineteenth century. It has been said that all subsequent biology has been a commentary on the *Origin of Species*; this is true in so far as the concept that all organisms are genetically related to one another became so generally accepted by the twentieth century that it could never again be ignored.

There were other unifying concepts, however, which the biology of the twentieth century inherited from that of the nineteenth: the concept of protoplasm as a common living substance composing all organisms;[1] the theory that the protoplasm of all organisms is organized into cells; the proof that, under conditions currently prevailing on the earth, cells can be formed only from other cells and life can proceed only from other life; the concept that all organisms undergo an orderly process of differentiation during their development from the egg; finally, the concept expressed by Claude Bernard (1813–78) that life, no matter what it may be, manifests itself in processes which conform to the laws of physics and chemistry. All these nineteenth-century synthesizing doctrines aided in the unification of biological thought and its focus on the study of common problems and new techniques of investigation.

The major problems to which biologists directed their attention were evolution and inheritance, cell biology, the nature of the living substance, and the question of the origin of life. These problems will be seen to be not strictly separable from one another; evolving organisms are constructed of cells, and cells are made up of protoplasm, and protoplasm uses the same kinds of atoms and molecules as compose the inanimate world. During the nineteenth century each major concept acted as a unifying device in its own limited area. It remained for the twentieth century to redefine these concepts and work out their interrelationships on a biochemical and an evolutionary basis.

I. HEREDITY AND EVOLUTION

Although Darwin presented a theory to account for change in organisms, he could not elucidate to the full either the possible or the actual mechanisms of

* This chapter was prepared by Dr. Jane Oppenheimer.

inheritance of variations. It was Mendel who postulated an explanation for the phenomena of inheritance in studies which were neither understood nor widely known during the nineteenth century. They were, as has already been noted, rediscovered and at last taken into account in the year 1900. The study of Mendelian inheritance from then on became a central discipline of twentieth-century biology, though geneticists of the USSR, particularly after 1936, postulated quite different non-Mendelian mechanisms.

1. *The theory of the gene*[2]

Genes were first given their name by Wilhelm Johannsen (1857–1927) early in the twentieth century, but the theory of the gene was crystallized by T. H. Morgan (1866–1945) and his co-workers during the first third of the twentieth century, in a series of experimental studies for which Morgan received the Nobel prize in 1933.

The improvement in the glass industry during the nineteenth century had led to the manufacture of achromatic lenses which allowed more detailed observations than had hitherto been possible on minute bodies within the nucleus of the cell. Before the end of the century the use of these lenses had demonstrated that the nucleus may be the seat of heredity and had suggested that visible bodies within the nucleus, the chromosomes, carry the factors of heredity.

Specifically, biologists learned during the last quarter of the nineteenth century that the number of chromosomes is normally constant for all the cells of each species, and described the mechanism whereby the chromosomes are duplicated lengthwise at cell division, one of each of the two new members being distributed to each of the two new cells. They further discovered, by the end of the nineteenth century, that another special mechanism comes into play during the cell-divisions which produce the male and female reproductive cells (gametes) which will combine to form the new individual; as a result of this, only half the typical chromosome number for the species passes into an animal's egg or spermatozoon, so that when these reproductive cells combine to produce a new individual, the chromosome number characteristic of the species is restored, the new individual has the same number of chromosomes as had each of its parents, and the infant receives half of these from each parent. An important summary and synthesis of this work was published in 1900 by E. B. Wilson (1856–1939) in his book *The Cell in Inheritance and Development*.

Microscopic studies of chromosomes carried out in the first decade of the twentieth century showed that sex determination in higher animals could be explained on a chromosomal basis. Each ovum (female gamete) or spermatozoon (male gamete) contains a specific number of chromosomes, later called autosomes, and in addition may also contain an additional chromosome, visibly distinct from the rest, the so-called sex-chromosome. In some forms, such

as grasshoppers, the sex chromosome carried in the ovum and always present in it is recognizable by its shape. Spermatozoa in this genus were shown to be of two kinds, one carrying the sex-chromosome and the other lacking it. If an ovum with its sex-chromosome is fertilized by a spermatozoon carrying another, the resultant organism is a female having two sex-chromosomes; the ova that she produces will necessarily have one sex-chromosome each. However, if an ovum containing a sex-chromosome is fertilized by a spermatozoon lacking it, the new organism has only one and becomes a male; half of its spermatozoa will receive the sex-chromosome and half will not.

Such studies gave an important visible clue to the fact that chromosomes might differ from each other in their specific hereditary functions, and the fact that the number of males and females in a species is approximately equal could be explained by random assortment and recombination of unitary elements of the cell, in this case sex-chromosomes, helping to determine sex. Thus a visible mechanism was described which assorted and recombined elements in exactly the way postulated by Mendel's hypothesis, and biologists soon recognized the chromosomes as the carriers of the genetic factors. It was found that many of the other chromosomes of various species could be recognized by their size and shape. In this way it became confirmed that the chromosomes are present in the adult nucleus in pairs, the two members of the pair being homologous, one member of each pair having been derived from each parent.

Morgan's work definitely showed that Mendel's factors—Johannsen's genes—are carried by the chromosomes. The principal contribution of Morgan and his co-workers was made by means of breeding experiments which could be related to what was known and what was still being learned microscopically about the chromosomes. Morgan found that the common fruitfly, *Drosophila melanogaster*, furnished ideal material for combined microscopic studies and breeding experiments. This species of fruitfly has a small number of chromosomes, four pairs, easily distinguished from one another by microscopic study. It breeds readily and quickly in the laboratory; and many of its genes undergo heritable change, either spontaneously or, as became apparent later, as a result of laboratory experiment, so that the results of the breeding experiments are easily detectable by simple examination of the flies.

In some of the early breeding experiments with *Drosophila*, Morgan and his co-workers observed, what had already in the first decade been suggested by William Bateson (1861–1926) and Reginald Punnett (1875–   ), that not all the factors they studied showed independent segregation and assortment, as would be expected from a strict application of Mendel's laws. In contrast, a number were inherited in groups. The chromosomes were known to assort independently of one another; and geneticists postulated that the factors associated with any one chromosome might tend to be linked together, independently of those associated with other chromosomes. If this interpretation was correct, *Drosophila melanogaster*, with its four pairs of chromosomes,

should have four separate groups of associated factors, and scientists found that this was the case. It had been Mendel's good fortune to choose for his studies on peas characteristics each of whose hereditary factors was located on a separate chromosome.

During the preparation of the reproductive cells, homologous chromosomes, one received from each parent, twist around each other, and during this process they break and interchange sections carrying homologous genes. Such exchange was first postulated by Morgan and his group as the only possible explanation of the results of some of their breeding experiments; it was later verified through microscopic study by Curt Stern (1902–) in 1930. Breeding experiments further suggested that exchanges between two chromosomes can take place at any region of the chromosome. If the position of the gene could be located, then by studying the frequency of exchange of particular chromosome parts, as detected in appropriate breeding experiments, the relative positions of the factors on the chromosomes could be worked out. In this way, Morgan and his co-workers mapped the chromosomes by establishing the relative position on them of the genes. These then became conceived as unit factors arranged linearly on the chromosomes.

Biologists soon demonstrated with clarity that genes sometimes exercise their functions during development by being responsible for the production of specific enzymes. Enzymes are organic catalysts, primarily protein in constitution, which are produced only by organisms, and which accelerate and facilitate the accomplishment of chemical reactions in the organism. They are of the utmost importance in all cellular functions, and the relationship of gene-action to enzyme-production in ascomycete moulds (George Beadle, 1903– and Edward Tatum, 1909–) was one of the important discoveries responsible for the central position of genetics among twentieth-century biological disciplines. It became possible to relate the effects of particular genes to the production of enzymes and other specific chemical syntheses when work on genes was extended to the moulds, and also to bacteria, since these can be grown in simple solutions containing known chemical nutrients. Here the effects of particular genes could be related to the pathways of specific chemical syntheses.

Since the nineteenth century enzymes had been known to be highly specific with respect to the conditions under which they operate and to the reactions in which they take part. Their selectivity was first explained by the characteristic shape of the protein molecules which are among their principal constituents. In addition, many other situations in which biological processes are highly specific, including genetic ones, were considered to be explicable in terms of the selectivity of protein reactions. This hypothesis was reinforced by the known importance of proteins in many of the highly specific immunological reactions by which the body combats bacterial and some other diseases.

During the early twentieth century scientists began to attribute increasing importance to the substances called nucleic acids in connection with genetic

action. These substances are able to self-replicate and to influence the manufacture of proteins (enzymes) with specific actions. While the nucleic acids had been discovered in the nineteenth century as important chemical constituents of nuclei, their chemical structure was established only in the twentieth; Albrecht Kossel (1853–1927) received a Nobel prize in 1910 for his part in its elucidation.

Biology had, in some of its phases, been dependent for its progress on previous findings in chemistry and physics or on their technological applications. This was particularly evident in the twentieth century when it became strongly dependent on elaborate physical instrumentation. The development of knowledge concerning the nucleic acids was a case in point. Through the use of ultra-violet spectrophotometry, Torbjörn Caspersson (1910–), around 1940, was able to study with great precision the amount of nucleic acids within cells, and this gave early evidence as to their function, particularly in connection with protein synthesis. Almost simultaneously Jean Brachet (1909–) worked out a new method of recognizing their presence in microscopic sections of tissues and thus of localizing them in various parts of the cell. He and Caspersson both emphasized their role in growth and reproduction.

Another of the clues to the importance of the nucleic acids in heredity was derived from a group of studies which at the outset seemed completely unrelated to the study of genes. These involved investigations of certain disease-producing agents, known since the nineteenth century as filterable viruses because they are so small that they pass through the filters used to strain bacteria from solutions during sterilization processes. Some of these viruses were shown during the 1930s to be nucleoprotein in nature, that is, to be made up of complexes of protein and nucleic acid. Some, such as that causing tobacco mosaic disease, could be crystallized, like inanimate matter, but could be reproduced only in living cells as a result of distorting the cell's own metabolism. They thus attracted great attention, as entities on the borderline between living and non-living matter.

A further important insight into the significance of nucleic acids in heredity was obtained in the 1930s from experiments in which it was shown that one strain of pneumococcus, a bacterium causing pneumonia, could be transformed into another strain by a chemical extract from the first strain which was later proved to consist almost exclusively of one type of nucleic acid, known as DNA (deoxyribonucleic acid). Later (1952) experiments with radioactive isotopes corroborated these results by showing that it was only the DNA in bacteriophage and similar viruses, and not its protein component, which entered host cells, there later operating to build its own characteristic protein. Many other types of experiments, notably quantitative studies on multi-cellular organisms indicating the relative constancy of DNA in the cells and its doubling or halving when chromosome numbers are doubled or halved, all supported the hypothesis that the DNA molecule is responsible for the self-copying and self-variation of living matter, and thus for heredity. (Pl. 5a.)

The DNA molecule was known to contain a number of different components. James D. Watson and F. H. C. Crick postulated in 1953 that it had a shape somewhat like that of a ladder with the uprights twisted spirally. The part of the molecule corresponding to the rungs, according to their model, is made up of nitrogen compounds which form complementary cross-links between the spiral parts of the molecule and assure its self-replication during self-division.

Scientists interested in applying mathematical communications theory to genetics postulated that the particular linear sequence of the different cross-links might act as coders of genetic information—in other words, genes. It appeared that DNA is the bearer of the specific genetic code, and that it is responsible for the formation of the various specific proteins in the body, via the intermediary of molecular templates composed of RNA (ribose nucleic acid).

Information theory as well as the results of some genetic experiments made it seem possible that within the DNA molecule the action of one group of cross-links might depend on that of its neighbour. According to this concept, genes might be groups of DNA cross-links, rather than relatively independent elements as Morgan's theory originally predicated. By the late 1950s, however, no one had fully demonstrated the exact relationship of the DNA molecule or its parts to the genes whose linear arrangement Morgan and his co-workers had demonstrated.

One advantage of the 1953 model was that it presented a possible explanation of how the DNA molecule, either in gene or virus, might be self-duplicated. An unexpected outcome of the studies on viruses was that some of them appeared to be similar to certain self-perpetuating particles, found in the protoplasm outside the cell nucleus and sometimes called plasmagenes, which seemed possible subsidiary agents in the mechanism of heredity. The study of the viruses thus made it appear that all control of heredity was not localized solely in the nucleus, as had been postulated at the beginning of the century. Since the evolution of life must have involved a stage in which molecules first became self-duplicating, genes, viruses and plasmagenes thus were brought close to the problem of the origin of life.[3]

Proof of the fact that a number of human attributes are controlled by specific nuclear genes separately or in combination—blood-groups, some kinds of colour-blindness, haemophilia—gave hope that a science of human breeding or eugenics might lead to the betterment of the human race. But the majority of thinkers viewed this possibility, though important, as distant of attainment, in view of the paucity of knowledge of human genetics and also in the light of the value judgments involved.[4] Nonetheless, eugenics became an active movement in the 1920s, and came to the fore again in Nazi racial policies. Later, pedigrees were drawn up indicating the inheritance of a number of human diseases or other abnormalities, and it was found possible to predict mathematically, in some cases with great accuracy, what the probable result of a given marriage would be. By the middle of the century a few advisory centres

were set up where such probabilities were calculated and reported to applicants who requested them. A number of cases are definitely known where specific deleterious effects can be guarded against. Although genetic prophecy can prove very accurate, however, it is never certain since it depends on probability theory.

2. *Variations and mutations*

A large body of evidence accumulated during the twentieth century linked the groups of studies on Mendelian factors with Darwinian natural selection.

Darwin recognized the fact that the essential basis of natural selection is that organisms vary and much variation is heritable. He did not exactly take variations for granted, but he had no clear and adequate explanation of their origin. While he depreciated Lamarck's theory as a whole, he accepted on a number of occasions the inheritance of characters acquired as a result of changed 'conditions of life'.

Towards the end of the nineteenth century August Weismann (1834–1914) cut off the tails of rats at birth for many generations and found that the offspring were nevertheless born with tails as long as ever. He explained this, and the non-inheritance of other mutilations such as circumcision, by the theory of the germ-plasm (1885), which contrasted the ordinary body cells of the organism with the germ-cells which would later give rise to eggs or spermatozoa and hence contribute to the formation of a new individual. This theory maintained that changes in the body cells do not affect the factors bearing the hereditary characteristics in the germ-cells and that if the progeny differs from its parents the germ-cells themselves and not the body housing them must have been altered. It was highly influential in establishing a climate of opinion for the acceptance of Mendel's work in 1900. This theory received a tremendous amount of observational and experimental confirmation during the whole first half of the twentieth century and was generally held by geneticists everywhere, except in the USSR after the late 1930s where, under the leadership of T. D. Lysenko (1898–), an opposed view accepting the inheritance of acquired characters became for some time the official doctrine of biologists in that country.[5, 6]

Hugo de Vries, one of the three re-discoverers of Mendel's work in 1900, made an important discovery when, by studying the evening primrose (*Oenothera*), he found various 'sports', plants not resembling their parents, some of which bred true in their changed form. He concluded that variation in organisms is produced not gradually but by sudden jumps, and he defined the process responsible for such change as mutation (1901). In the light of Weismann's theory it was recognized that mutation affects the germ cells, and it was postulated that all heritable change in organisms results from mutation, though mutation as commonly understood is a result of different processes than had occurred in the material studied by de Vries. True mutation, the process which results in alteration of the hereditary material, involves intrinsic change

in the substance or the pattern of the genetic constitution. What had been responsible for the effects observed by de Vries were occasional cross-overs in a very peculiar type of gene-complex.

There were thus found to be two sources of variation in organisms. One was based on the shuffling and recombination of the hereditary factors during the preparation and random combination of the germ-cells, the other on actual alterations of the factors by mutation. Mutations in some cases affect the genes themselves, producing different gene-alleles. In others they involve changes in the number of chromosomes or of chromosome sets, or changes in the arrangement of genes within the chromosome (inversions, translocations etc.).

The mutations studied by de Vries appeared to him to arise spontaneously, that is, the cause of the occurrence was not discovered until later, and subsequently many other apparently spontaneous mutations were observed. As mentioned above, the early work of Morgan and his co-workers on the fruitfly proved successful in part because the rate of spontaneous mutation in this animal is relatively high under laboratory conditions. Great impetus, however, was given to the further investigation of heredity when Hermann J. Muller (1890–) discovered in 1927, by a study involving a masterly mathematical analysis and equally masterly experimental methods, that the rate of mutation in the fruitfly might be appreciably increased by the use of X-rays. Later studies by a number of workers showed that the mutation rate could be increased, or new mutations produced, or both, depending on the treatment and the organism used, by other ionizing radiations, or by ultra-violet light, or by high temperature, or even through the application of certain chemicals. The nitrogen mustards prepared for use as poison gases were among the first of the chemical substances to be proved effective.

The discovery of artificial methods of inducing mutations was very valuable for the progress of genetics, but by the middle of the century it did not yet explain the causes of the so-called spontaneous mutations. Most mutations are gene mutations. After the discovery of the importance of DNA for the transmission of hereditary characteristics, it was postulated that mutations might affect the order in which some of the basic constituents of the DNA molecule, the cross-links, are arranged in sequence, or their detailed structure.

Scientists had not, by the middle of the twentieth century, found it possible to control the kind of mutation produced except to a very small extent. They had demonstrated that most mutations, spontaneous or induced, are harmful to the organism, but by selective breeding some of the advantageous ones, or combinations of them, were being put to the service of man, as in the increase of the frequency of egg laying in hens or the production of butter fat in cow's milk.

A vast amount of discussion as to the power of man to influence the production of mutations followed the first explosions of atomic and hydrogen bombs. Since ionizing radiations had been shown to be the most potent agents producing mutations in the laboratory, it became clear that the increase of such

radiations as a result of bomb explosions was a potential danger with respect to health and normality, and to the perpetuation and further evolution not only of man but of all living creatures. Similar peril was seen to be inherent in the increase of exposure to ionizing radiations through excessive use of X-rays and other radiations in medicine and industry and through the peaceful uses of atomic energy if not properly safeguarded.

3. *The course of evolution*

The evolutionary effects of mutations were considered in the twentieth century to be mediated by selection. Organisms produce more young than can survive. They vary, and some variations are heritable. Therefore, on the average, more favourable ones will survive to reproduce. Darwin had taken one of his principal clues from an analogy between selection by the domestic breeder and that by nature. The discovery and analysis of mutations finally permitted the elucidation of the change studied by evolutionists in terms of the mutations studied by geneticists. The biologists of the first half of the twentieth century accepted the theory that natural selection acts, with results for the future, upon heritable change occurring through mutation as well as through recombination, and calculations were published in the 1940s indicating that what was known of the age of the earth and of the fossil history of organisms, together with what was known of rates of mutation, was compatible with this theory.[7]

There were many studies of the course of evolution and its operations. Three main trends came to be recognizable: (1) branching evolution leading to diversification, (2) upward evolution leading to improved adaptation and specialization, and (3) limiting evolution leading to stabilization of type. George Gaylord Simpson (1902–) was able to calculate rates of evolutionary change in different groups.

Darwin realized that selection by nature was a process involving populations; in fact one of the main ideas leading him toward the development of his theories was Malthus's generalization concerning the rate of increase of human populations relative to resources. The development of new concepts concerning evolutionary mechanisms provided another example of the dependence of twentieth-century biological progress on mathematical theory. R. A. Fisher, J. B. S. Haldane (1892–) and Sewall Wright (1889–) in the 1930s all developed, independently and nearly simultaneously, mathematical theories responsible for the beginning of a new branch of biological science, population genetics, which dealt with the heredity not of individuals but of groups. From this arose the concept of the gene-pool, or the totality of all the genes and their various alleles of all the organisms making up a population. This became a new frame of reference against which mutations were evaluated, and it became clear that those mutations in the gene-pool would be selected which would enable the population to reproduce most successfully under whatever conditions it existed in nature.

An important result of the concentration of attention on populations was a change in the basis of classification. From the time of Carolus Linnaeus (1707–78) through the greater part of the nineteenth century, biologists had considered the species the fundamental unit of biological classification, a fact which was recognized by Darwin when he chose the species as the focus of his own thinking. The criteria for the classification of organisms changed in a number of ways during the twentieth century. They were no longer limited to the visible characteristics of organisms or their parts as before; as advances were made in embryology, physiology, ecology, biochemistry and immunology, the criteria were extended to include data from more varied aspects of the life of organisms. In addition, under the influence of population genetics, species became defined as reproductive communities sharing actually or potentially a common gene-pool, and the probability of the selection of particular factors was analysed from a statistical point of view. Furthermore, since the mathematical studies suggested that selection in populations varies under different conditions, classification in particular and biology in general turned during the twentieth century to new dynamic studies of populations of organisms in relation to their wider environment.

4. *Ecology*[8]

Biologists have always had to be concerned in some way with the relationships of organisms to their surroundings, since it is a principal feature of living beings that they are in a continuous state of balanced interaction with such surroundings, including other organisms. Darwin fully appreciated the complexity of the relationships of various groups of organisms to each other and to their surroundings of inanimate nature, and wrote what remained one of the best accounts of the subject.

It was however largely within the twentieth century that the study of the relations between organisms and their environment became codified into the formal science of ecology. The subject acquired great practical importance when chemicals came to be employed extensively to eradicate pests or weeds, or predators were introduced to wipe out pests of a particular species, for these measures affected the balances of populations within an area. At the beginning of the century ecology was predominantly botanical. Henry Cowles (1869–1939), Frederick Clements (1874–1945) and Sir Edward Salisbury (1886–   ) were leaders of schools attempting to understand plant communities. Cowles made the first good studies of the succession of plants from first colonizers through dense forest; Clements made challenging generalizations about the climax which is the final, unchanging stage in succession; Salisbury used these and other results in interpreting British habitats. Plant ecology progressed but little beyond the work of these men. Perhaps the most striking improvement was the result of the expansion of forestry as a subject for research. Modern foresters understood something about the environmental conditions under which different trees flourish.

At the same time, investigators transplanted plants to new environments and so studied the genetic nature of these adaptations to different habitats.

Beginning seriously with studies by E. A. Birge (1851–1950) and Chauncey Juday (1871–1944), important work was carried out on organisms living in lakes. Since a lake is a smaller body of water than an ocean and more narrowly confined, it can be more easily studied as a whole. Limnology, the field of ecology dealing with lakes, made great progress not only in describing the chemical constitution of a lake, but also in analysing its change, becoming almost a study of the metabolism of lakes. This work led to studies on the land and in the ocean in which the names of species play little role, but the numbers of species and their rate of energy consumption are considered. In these studies, natural communities are considered as heat engines transforming energy, ultimately derived from the sun, into living matter. Thus much attention was paid in marine ecology to the conditions governing the abundance of plant plankton, on which all pelagic marine animals depend.

Two new approaches to ecology emerged from the late 1920s. One was centered about mathematical deductions from simple assumptions about the interactions of species. This is profitable because even simple interactions seem too complicated for the mind, unaided by mathematics, to grasp. Consequently, in the hands of Alfred Lotka (1880–1949) and Vito Volterra (1860–1940), some quite unexpected predictions were made from simple assumptions. These assumptions were thereby made testable. This work was the origin of the subject of cybernetics, which became popular in its own right. Subsequently, their work was made more general in the attempt to find necessary and sufficient conditions for populations to oscillate and for stable equilibria.

Coupled with the mathematical approach, laboratory studies of confined populations sought to test which of the mathematical models could be realized with real populations. G. F. Gause (1910–) was the most prominent of these laboratory investigators. He was able to show that animal populations are able to change in most of the ways suggested by the mathematicians.

A reaction, however, set in, questioning whether these population interactions, predicted by mathematicians and shown to be possible in laboratory experiments, actually play any part in nature. This reaction on the part of field investigators led to a reanalysis of the mathematical models and laboratory verifications.

Finally, relationships of organisms to one another in the field were investigated, not only as population-problems but in terms of behaviour patterns, in a branch of biological science known as animal behaviour or ethology.

5. *Ethology: studies on animal behaviour*

Darwin had considered sexual selection to be one mode of action through which natural selection operated. He postulated that the display patterns of male birds, for instance, in species in which the male is brightly coloured and

the female drab, evolved as a result of the preference of female birds in that species for bright colour; that is, if two males were competing for a female's favour, according to Darwin's theory, she would choose the more brightly coloured for her mate, and thus the quality of brightness of colour would be passed on to her offspring. Many biologists saw two fallacies in this argument. First, a brightly coloured male might not necessarily have offspring all as brightly coloured as himself. Secondly, this concept was taken by some to attribute to the female bird the same aesthetic tastes and appreciations that characterized her human observers. The tendency to endow other animals with subjective reactions similar to those of man became known as anthropomorphism and was soon recognized as a principal hazard in the interpretation of animal behaviour. The ability to discriminate colour patterns, and in some cases to prefer them, can however be demonstrated on non-anthropomorphic grounds.

In the early part of the twentieth century Julian Huxley (1887–) observed and described the highly complicated and seemingly bizarre behaviour patterns indulged in by the male and female great crested grebe during the breeding season. In these diving birds the two potential or actual mates perform, as in a ritual or dance, a sequence of different actions. Many of these activities, such as diving, erecting the crest, lowering the head or spreading the wings, result in one bird presenting in turn strikingly different visual appearances to the other. Huxley's interpretation of such display as a factor in sexual selection was somewhat different from Darwin's. He considered that the display of one bird stimulated the opposite sex partner in a combination of emotional, nervous and biochemical ways.

This postulate permitted the analysis of animal behaviour in less anthropomorphic terms than had previously been practised. Further encouragement was given to the pursuit of such studies when Konrad Lorenz (1903–) named and analysed the phenomenon of imprinting, long familiar to farmers and other breeders of birds and barnyard animals. The reason that a duckling normally follows its mother is that she is the first organism of a certain size it sees when it hatches from its egg. Lorenz showed that if it sees for instance a crouching man before it sees a duck, it follows the man as it would have followed its mother; the duckling need only see the object for a short time in order to establish this pattern of behaviour.

Ways by which organisms give clues to one another in many aspects of their behaviour were studied subsequently in many countries and were incorporated in a sort of sociology of nature. One great significance of the development of ethology was that, at a time when much of biology was becoming narrowed to examination of parts of organisms by complicated laboratory instrumentation, it, like the new classification, encouraged many investigators to return to the study of the behaviour of the whole organism in its natural surroundings. Comparative studies of behaviour patterns in a number of related species proved especially rewarding. In other words, even in the twentieth century

biologists were continuing to develop fundamental concepts through studies made without complicated equipment and carried out by techniques peculiar to biology.

Ethologists in some cases performed experiments simple in type, either in the field or in the laboratory. For example David Lack (1910–) confronted a male European robin, a bird which fights with other male robins during the breeding season, with both an isolated patch of red breast feathers and a complete stuffed juvenile robin which had no red breast, to ascertain which of these he would attack. Such studies led to the important concept of specific patterned 'sign-stimuli' acting as 'releasers' of specific patterns of activity. The acutal mechanisms within the robin culminating in the attack on the patch of red feathers could be inferred, but it was more difficult to explain other patterns of behaviour, such as the pulling up of grass by a sea-gull in the middle of a fight. Nonetheless, the study of such 'displacement activities' which occur when there is conflict between opposing drives showed promise of increased understanding of animal behaviour.

From the beginning of the century studies on instincts and learning in animals were performed by psychologists as well as by biologists. In studies of learning processes in rats, they discovered that if appropriately rewarded with food for correct performance or punished with slight discomfort, as for instance by a light electric shock, rats could quickly learn to follow mazes or perform other feats. These results indicated the importance of motivation as a factor in learning, at least in rats.

Other students of animal behaviour towards the middle of the twentieth century analysed particular behavioural mechanisms in other types of organisms. J. Z. Young (1907–), for instance, studying the behaviour of the octopus, observed its alterations after the removal or separation of particular parts of the nervous system, and studied the latter by some of the electrical methods first worked out for the study of mammalian brains. Ornithologists showed that in birds day migrants orient themselves with reference to the sun, night migrants with reference to the pattern of the constellations. Some brilliant and successful studies of animal behaviour were made on honeybees by Karl von Frisch (1886–) who discovered experimentally that bees know the direction to follow between hive and food through their ability to analyse the degree of polarization of light from the sky, and the distance between them through some internal nervous mechanism. He found also that they are able to communicate to other members of their community, by executing various movements in a dance, both the direction in which food might be found and its relative distance from the hive. This was a set of processes which to some biologists indicated that bees in their own way might have evolved the powers both to make abstractions and to symbolize them, abilities which had previously been considered the prerogative of man alone, though the symbolization was recognized as controlled genetically and not built up artificially as with human language.

6. *Biological and evolutionary aspects of human behaviour*

Much progress in the biological study of human behaviour was made possible after the end of the nineteenth century by great improvements in methods of operating on the nervous system. The functions of the mammalian and human nervous system became open to experimental investigation only after the perfection of the techniques of anaesthesia and asepsis extended the range and safety in surgery. In addition, such experimentation was facilitated by the increasingly mechanistic outlook and the new knowledge of man's position in the animal kingdom, which made it possible to study human behaviour by the same objective methods as that of other organisms.

Physiologists during the nineteenth century had carried out operations on the nerves entering and leaving the spinal cord in animals. Their results indicated that different sets of nerves are responsible for carrying sensory and motor impulses related to sensation on the one hand and to muscular activity on the other. At the beginning of the century, C. S. Sherrington (1857–1952), who received the Nobel prize in 1932, performed operations on animals which excluded the brain from its control over the spinal cord, and he thus was able to demonstrate the degree to which the spinal cord independently of the brain could co-ordinate complex and purposive actions, such as scratching. He interpreted his results in terms of the integrative action of the reflex pathways in the cord involving both sensory and motor components.

Knowledge of the reflex and its separate components actually dated back to the nineteenth century, but its significance was demonstrated by Sherrington's experimental studies, and the concept was to be responsible for a number of important later investigations directly related to human behaviour. Anatomists, who knew that the spinal cord receives and gives off separate sensory and motor components, localized these pathways within different regions of the cord. This made it possible to demonstrate comparable pathways in parts of the brain and thus to elucidate the function of its different parts. These pathways are not directly evident as a result of simple inspection or dissection of the human brain, which has a very much more complicated organization than the spinal cord. They were, however, worked out by comparison with brains of other simpler vertebrates and especially by comparison with embryonic brains of both simpler vertebrates and of man himself, where the relations are also more simplified. Thus, neurologists and neurophysiologists learned the functions and began to understand the interrelations of many of the groups of cells and bundles of nerve fibres within the human brain which had hitherto been only surmised as a result of studies on brain damage. These clinical results had often previously been difficult to interpret since most accidents and diseases may involve several adjacent parts of the brain rather than only a single one.

The cerebral cortex, or outer layer of the forebrain, is the part of the brain that is relatively larger in mammals than in other vertebrates and relatively larger in man than in other mammals. In man it consists of approximately

10,000,000,000 cells, three times as large as the human population of the globe. Surgical removal of parts of the cortex of the human brain also shed light on the functions of various parts of the brain with respect to sensation and movement. The greatest progress was made, however, when brain surgeons discovered that electrical stimulation of the brain surface could be carried out safely and painlessly in conscious patients. While the results of stimulating the part of the cortex controlling muscular activity could be observed as successfully on other mammals as in man, only man can describe to the surgeon his sensations when the parts of the cortex responsible for them have been stimulated. The results of electrical stimulation demonstrated the degree to which control over various activities is localized in the cortex.

Curiously enough, investigators showed that the particular part of the cortex, the prefrontal area, that is relatively largest in man as compared with other vertebrates, is singularly unresponsive to electrical stimulation. While many had postulated that, because of its size, it was the seat of the highest intellectual activity, its electrical stimulation not only did not give rise to the production of ideas, but did little else except for a few minor portions which are involved in the control of motor activity. In fact, surgeons did not find that stimulation of any part of the cortex caused thinking, although in epileptic patients stimulation of certain areas within the temporal lobe enabled the patient to recover detailed memories which had become unavailable to him. The brain surgeons found also that neither the prefrontal area nor any other particular part of the surface was responsible for the production of consciousness as such, long considered one of the higher functions of the human cortex. They found no particular area of the human cortex which when stimulated would awaken sleeping or otherwise unconscious patients.

Experiments on animals, however, led towards knowledge of some of the mechanisms with which consciousness is associated. These took advantage of the fact that the brain, like other parts of the organism, is characterized by changes in electrical potential. The electrical changes in the heart were studied by physicians using a technique made possible by the advances in physics which permitted detection, amplification and recording of the change in electrical potential of the heart muscle. Other studies by physiologists demonstrated that the nerve fibre conducts its impulse by means of the passage of a wave of electrochemical change. During the 1920s Hans Berger (1873–1941) discovered that changes in the electrical potential of the brain as a whole took the form of rhythmic waves which could be measured by electroencephalography, just as the electrical changes characteristic of the heart muscle had been measured by electrocardiography.

Although the details of the production of the electrical changes in the brain were not understood by the middle of the twentieth century, nevertheless much was learned from the study of the pattern of the waves, which differ in various parts of the brain and in different states of the organism. Most important, the study of electrical changes demonstrated the intimacy of the relations

between the cortex and underlying parts; stimulation of the underlying parts changed the electrical wave patterns of the cortex. Physiologists thus learned that the cortex does not work alone in the control of behaviour, but in co-operation with deeper-lying brain parts. It is, for instance, the pathways between the prefrontal cortex, found to be largely unresponsive to electrical stimulation, and a particular underlying part, the thalamus, which are cut by the surgeons who perform frontal lobotomies to relieve the anxieties of some mentally disturbed patients. Furthermore, by means of the combined electrical stimulation of deep-lying parts of the brain in animals and study of the accompanying changes in electrical pattern of the cortex, it was discovered that particular areas deep within the brain, whose activities had not been adequately investigated before, are responsible for waking the brain and holding it in a state of attention.

Not all the studies on human and animal behaviour carried out during the twentieth century depended so exclusively as these on combined surgical, physiological and anatomical methods. Others of equally great significance supplemented these with different techniques. Among the most important and fruitful were the studies leading to the concept of the conditioned reflex for which Ivan Pavlov received the Nobel prize in 1904. Towards the middle of the century study of electronic circuits involving the feedback of information to control the circuit and the development of mathematical theories of communication led to the framing of analogies between the brain and computing machines. The principles of cybernetics provided a possible explanation of how much of man's highly complicated behaviour might be explained by the complexity of circuits in the cortex made up of almost ten thousand million nerve-cells, most of which have multiple connections.

Finally, by the middle of the twentieth century, the brain and its functions, like most other biological systems, became subject to chemical study. Drug action, in the case of opiates for instance, had been known from time immemorial to cause changes in mental activity. During the twentieth century physicians learned to produce changes in mental activity accompanied by less drastic physiological effects through the use of the tranquillizers. They administered chemical substances such as dilantin which in many patients were successful in the control of epileptic seizures. In addition, metabolic studies of the brain began to suggest correlations of the quantity of specific substances, for instance serotonin, with variations in mental function, and many physicians looked towards biochemistry for the diagnosis and cure of hitherto unexplained and intractable nervous and mental diseases, notably schizophrenia.

Advances in knowledge of brain structure and function were not unrelated to evolutionary studies. Some biologists have considered the specifically human mental capacities for intelligence, imagination and conceptual thinking to represent the highest achievement of evolution. In any case man, by means of the use of his mental capacities, has become the latest dominant type in evolution. It was generally agreed among biologists by the middle of the

twentieth century that man was by then, and would continue in the future to be, responsible not only for his own destiny but also for that of the rest of earth's organisms.

II. CELL BIOLOGY

One of the principal unifying practices of twentieth-century biology was the explanation of physiological processes in terms of the actions of cells and cell systems. This followed the introduction of the functional outlook into biology through the development of physiological studies which was one of the chief features of late nineteenth-century biology.

Investigations on the nervous system, among many others, exemplify this tendency. Nineteenth-century physiology and surgery made the nervous system accessible to experimental investigation; studies on tropisms encouraged biologists to think of the operations of organisms and their parts as mechanical processes, and thus opened the way philosophically for new interpretations of behaviour, including that mediated by nervous action. The twentieth-century scientists analysed the functions of the nervous system not only by defining its cellular components according to anatomical and embryological criteria, but also by seeking to determine, through electrical and chemical studies, how each cell carries and transmits the nerve impulse to the next. Biologists of the nineteenth century had established the cell as the basic structural unit of the nervous system; those of the twentieth century analysed it as the functional one. Thus they replaced the static concept of the cell by a dynamic one, not only in connection with the nervous system but for all cells, whether these are parts of many-celled organisms or are one-celled organisms in their own right.

Twentieth-century biologists did not however abandon structural study of the cell when they embarked on their biochemical studies of its functional processes. In fact advances in the physical sciences were responsible for such improvement in instruments used for biological observation that many of the nineteenth-century observations on cell structure required almost completely new interpretation. (Pl. 4a, 5a, 5b.)

One of the important new instruments was the phase microscope, invented by F. Zernike (1896–), which employed a different system of optics and thereby made visible smaller changes in refractive index than did the conventional microscope. This proved of particular advantage for the study of living cells in tissue culture and independent unicellular organisms. In the 1950s an X-ray microscope was put on the market which showed great promise for the more detailed study of many-celled organisms of small dimensions. But in some ways most important was the introduction of the electron microscope, which permitted the examination of objects, though unfortunately not in the living state, up to a magnification of 100,000 to 200,000 times, in contrast to the magnifications of 1,000 to 1,500 times which were high for the conventional light microscope. By the middle of the century biologists had made a number of important discoveries through its use. They demonstrated that the

animal cell membrane is far from the simple wall it had once been considered to be, as is likewise the nuclear membrane separating the nucleus from the rest of the cell. They showed the cytoplasm of the cell to be far more complex than hitherto postulated. They also showed that some of the particles included in the cytoplasm, especially the mitochondria, which are of interest because of their universal distribution in cells of the most varied types, are complicated structures with considerable organization in their own right.

Other advances in physical instrumentation, particularly the invention of the ultracentrifuge which separates broken cells into their constituents by whirling them at a rate of 6,000 or more revolutions per second, made possible the isolation of many kinds of intracellular particles. Biochemists, taking advantage of high-speed centrifugation, demonstrated that isolated mitochondria were the seat of some of the fundamental biochemical mechanisms used by cells to release energy for the life-processes, and biologists postulated which parts of the mitochondria, as known through electron microscopy, might be involved. Such studies made biologists much more conscious of the great complexity of cells.

1. *Differentiation in developing organisms*

Work along a number of lines was responsible for developing an understanding of the general mechanisms by which the organism as a whole and its constituent organs, tissues and cells, operate as units of function.

At the beginning of the twentieth century experimental embryologists, following along the way opened by Wilhelm Roux (1850–1924) and Hans Driesch (1867–1941), made particular innovations in the study of how embryos and their parts become differentiated. Their predecessors had established firmly, by descriptive methods, the concept of progressive differentiation. According to this principle, the fertilized egg in the many-celled organism passes through a series of processes, each one causally dependent on immediately preceding processes. This integrated chain of reactions is responsible for changing the apparently simple egg cell into the specialized and complicated adult whose component cells are structurally and functionally adapted for their special operations. Since, as Henri Milne-Edwards (1800–85) had already emphasized, the organized life of the organism depends on the division of labour among its cells as well as on their integration, the study of the chains of processes whereby these attain their final specialized and integrated state was viewed as one of the key problems of biology, and embryologists devised many new and original methods for its investigation.

Tissue culture, one of the most ingenious of these methods and also one of the most fruitful, was originally developed in order to clarify the exact mechanism of formation of the nerve fibre. It was one of the more curious ironies of biological history that when Schwann formulated the cell theory in the nineteenth century he imagined the nerve fibre, in the face of much evidence to the

contrary, to be the product not of a single cell but of many. The controversy as to the precise origin of the fibre was settled only by the introduction in 1907 of the tissue culture method by Ross G. Harrison (1870–1959). Harrison, in order to confirm his belief that the nerve fibre is an integral part of the nerve-cell itself, produced by it and not added on to it by other cells, developed a simple technique whereby he removed from a frog embryo a young nerve-cell before any nerve fibre had been formed. He allowed the young nerve-cell to develop in clotted frog lymph in a microscope slide and he found that it formed a fibre itself in the absence of the other cells which Schwann had postulated as making it.

This simple experiment not only firmly established the nerve-cell as the structural and functional unit of the nervous system, but provided a method which for the first time permitted detailed studies of living cells under conditions controllable by the experimenter. For some years the new method was not so successfully exploited as it might have been. By the 1930s, however, embryologists began to use it effectively to examine the degree to which the early differentiation of cells is controlled by factors resident in the cells, as compared to factors in their environment. They showed that in some tissues and some organisms external factors are more important in influencing differentiation than in others; and that cell types are more susceptible to such influences at younger stages than at older ones.

By the middle of the century, when biologists had become more chemically minded, they took advantage of their ability to grow cells in an artificial environment of known chemical composition, and the method became of more value for the study of plant and animal growth and differentiation, normal and abnormal. It was used to grow cells in which viruses were propagated, and thereby contributed much not only to the theoretical understanding of virus reproduction but also to the control of virus diseases, for instance in the development of the Salk vaccine against poliomyelitis. Later, in the 1950s, experts were able to grow in tissue culture colonies or populations of human cells, each produced by cell division from a single isolated human cell, a technique which promised to provide much information not only concerning normal and abnormal growth of human cells but also as to the role played by mutation during continuous cell division in producing abnormalities of growth and development.

While the tissue-culture experiments enabled investigators to observe the differentiation of various types of cells under a wide variety of chemical conditions, they did not, at least at first, permit investigation of the stimuli which promote differentiation. This problem was approached in a different way. The studies on the fertilization of the egg which had been carried out during the previous centuries had established that it is normally the entrance of the spermatozoon into the egg which initiates the development of the latter. Investigators at the turn of the century discovered that some eggs could be activated to begin their development and differentiation, in the absence of the

spermatozoon, as a result of various changes in the chemical and physical surroundings of the egg. This process was called artificial parthenogenesis, and early in the century biologists attempted to find out the exact mechanism of artificial parthenogenesis in animals. Different methods were used with success on different kinds of eggs—changes in temperature, changes in the salt concentration and constitution of the surroundings, changes in their acidity or alkalinity, and in some cases merely shaking or pricking the eggs. These experiments failed to isolate one factor common to them all, and the hope was soon destroyed that there might be a simple explanation of the parthenogenetic effect. Embryologists therefore finally became reconciled to the concept that the entrance of the sperm might be a trigger which set off a chain of reactions in the egg which could also be started by a number of other triggers which seemed to have little if anything in common.

The efforts to determine the mechanisms of fertilization, however, brought some important practical and theoretical advances. Animal breeders found that spermatozoa, even of mammals, could be frozen and chemically treated and stored for later use, and artificial insemination was employed with great success in the breeding of some domestic animals, cattle in particular. In a number of cases artificial insemination was used in human reproduction when sterility prevented normal conception.[9]

On the theoretical side one of the more fruitful results of the fertilization studies stemmed from consideration of the high degree of selectivity of the fertilization reaction, which normally prevents the egg of one species from being fertilized by the spermatozoon of another. Frank R. Lillie (1870–1947), during the first quarter of the century, postulated that this selectivity was controlled by the same kind of reaction which is responsible for the antigen-antibody relationship in immunization against disease, where antigen and antibody interact with great selectivity, presumably because of the shapes of their protein molecules. By the middle of the twentieth century embryologists were studying the possibility that the differentiation of embryonic cells might be controlled in part by the production within the embryo of substances acting like antigens, and such antigens were demonstrated to exist, for instance in the case of the lens of the eye.

Embryologists also used other methods to study differentiation as controlled by factors within cells and, in fact, to some degree its initiation. By the close of the nineteenth century they had begun to develop a technique for transplanting groups of cells from one embryo to another. Tissue-culture experiments deprived cells of their normal cellular surroundings in the embryo; grafting experiments gave cells new cellular environments by placing them in different parts of eggs. It thus became possible to study interactions between new and different combinations of cells and tissues.

By performing such experiments embryologists were able to demonstrate that in the eggs of some species one group of cells could influence another group of cells to differentiate in a manner they would not have done in

the absence of the first group; this process was called embryonic induction.

Induction was first analysed, with particular brilliance, during the first third of the century by Hans Spemann (1869–1941). Spemann's first grafting experiments showed that a part of the salamander brain which later becomes the retina of the eye induces the skin lying over it to form a lens. When he transplanted flank skin over this part in a young embryo, the flank skin formed a lens. These experiments were the basis for the concept of induction. A few years later he showed that one part of the very early salamander embryo, if grafted to another salamander egg in the same stage of development, would induce the host to form a second embryo. This region he called the 'organizer'. If the organizer, which acts only during early embryonic development, was divided into two parts before cellular differentiation was completely under way, a single egg could be formed into two embryos rather than one. These results validated experimentally the concept of progressive differentiation according to which each step of development is causally related to the preceding step. Spemann was rewarded with a Nobel prize in 1936.

In the following years embryologists tried to discover the mechanisms by which induction occurs. This was also the period during which interest in biochemistry was burgeoning among biologists. When embryologists showed that dead organizer cells could induce new structures to form, and that even other killed cells from a great variety of organisms, such as guinea-pig liver or mouse kidney, could cause inductions in salamander eggs, they began to search for a particular organizer substance which might be common to all the kinds of cells that had been effective, dead or alive, in producing inductions.

They found, however, that many different chemical agents were successful in producing induction in living eggs or in tissue culture (digitonin—a protein, fatty acids, nucleic acids, a class of organic compounds called steroids, and a number of others). They finally admitted, therefore, that the organizer does not act through the production of a single simple organizing substance, but that various substances can somehow serve as physiological triggers. In the 1950s chemical embryologists were concentrating on the roles of proteins and nucleic acids in induction. Some preliminary but inconclusive attempts were made to ascertain by the use of radioactive isotopes whether such substances or their parts actually passed from inducing cells to those induced to differentiate. Other biologists attempted to discover, by the use of filter membranes with a minute pore of known size, if actual protoplasmic continuity between induced and inducing cells was necessary for induction, and presented some evidence that this might be so.

In fact, however, important genetic studies involving developmental interpretations had been begun long before embryologists were driven to an impasse by the chemical work on the organizer. Richard Goldschmidt (1878–1958) in his important work on sex differentiation in the gypsy moth had

already in 1916 attributed great importance to the developmental actions of genes and had explained these functions quantitatively in terms of enzymes; Sewall Wright in the same year discussed the inheritance of coat-colour in the guinea-pig from a developmental point of view. But such contributions were sporadic, in part because little was yet known about the embryonic development of the organisms such as *Drosophila* that were best known genetically; and the genetics was not yet known of those best known embryologically, such as the amphibian and the echinoderm. By the middle of the century, however, combined embryological and genetic studies were being carried out on *Drosophila* (Donald Poulson, 1910–), Curt Stern, Conrad Waddington, 1910–), Ernst Hadorn, 1902–), on salamanders (Rufus Humphrey, 1892–), Victor Twitty, 1901–), on chickens (Walter Landauer, 1896–) and on mice (Leslie Dunn, 1893–).

Other developmental studies carried out during the first half of the century ran parallel to those on organizers and genes, but had not yet converged with these by mid-century. These involved the concepts of gradients and fields. Gradient theory implies that the form or pattern of differentiation is set by a system of gradients and fields involving metabolic differences of various sorts.

Polar differentiation of the egg was first discussed in the nineteenth century by Karl von Baer (1792–1876), and Driesch too was much interested in it. Boveri, through his interest in polarity, studied the stratification of visible substances in the egg and introduced the concept of the gradient to explain it in 1910. Very shortly after, in 1911, Charles Manning Child (1869–1954) used the term 'axial gradient' in connection with studies on regeneration, but later applied it to embryonic development. Child considered his metabolic gradients to have their basis in higher rates of oxidation at one pole. While more refined studies later in the century failed to confirm this, his work was of great importance in opening the way toward the metabolic and biochemical interpretations of development that were to become so popular later in the middle of the century.

The field concept encompassed both the axial gradient and organizer concepts. The first ideas responsible for this, though not the name, emanated from the work of Ross Harrison on the development of the amphibian limbs in 1918. In 1921 Hans Spemann considered that the organizer acted by producing a general field of organization; in later stages of development, fields of organization appear in relation to all the main organs, such as limbs.

Field theory was first generalized to cover a number of developmental phenomena by Paul Weiss (1898–) in 1926; eight years later Julian Huxley and Gavin De Beer (1899–) accounted for a number of developmental data on the basis of what they call gradient-fields, a combination of gradient and field theory. Huxley stressed the importance of gradient-fields in relation to the differential growth of organs and their parts; in molluscan shells such as snails', two growth-gradients operating at right angles determine the characteristic spiral form.

Another basic feature underlying differentiation, established by Waddington, was the channelling of the differentiation of particular organs along well-defined developmental pathways. These are biochemically self-regulating, so that it is difficult for the process to be deviated by environmental agencies and produce an abnormal result. Once the operational unit was identified, embryologists began to identify some of the biochemical and metabolic process involved.

The studies on induction were performed on developing animals. In plants some aspects of growth were more successfully demonstrated to be under the control of known chemical agents. The study of tropisms in the nineteenth century had indicated the degree to which plants were dependent on external stimuli for the direction of their growth, and the tropism theories postulated mechanisms whereby the sunflower turns towards the sun as a response to light and roots grow downward in response to gravity. Plant physiologists in the twentieth century further explained some of these phenomena in terms of the unequal growth of parts of cells, and showed, moreover, that such differential cell growth was caused by the action of specific chemical substances produced in other cells of the plant. These substances, the plant hormones or auxins, were not only chemically identified but were actually synthesized in the laboratory.

2. *Chemical integration: animal hormones*[10]

Before the existence of plant hormones was suspected, physicians and physiologists had demonstrated some actions of hormones in man and other animals. Animal hormones are defined as substances, made by special glands, which are liberated into the blood stream and act as chemical co-ordinators by affecting various other organs. Physiologists during the twentieth century showed that hormones are present and active not only in vertebrates but also in some invertebrates, where they control colour change, moulting and other processes; the same hormone sometimes acts on different tissues, and therefore produces different effects, in separate groups of animals. In many cases the hormones seemed also to act as triggers; in a very few cases their specific biochemical action became known.

These chemical agents came to be recognized as of the utmost importance in preserving the constancy of the internal environment in vertebrates and later in other higher animal types. Their significance was dramatized by the action of some hormones, for instance that of thyroxin, the hormone of the thyroid gland, in producing physiological changes both so drastic and so subtle that they affected even human personality. When such hormones as thyroxin were not only chemically identified but synthesized in the laboratory, the importance of chemical control in the co-ordination of even the most complex functions of complicated organisms was brought home to biologist and layman alike. This importance became still further appreciated when it was discovered that the nervous system also, the other great co-ordinator

of body action, transmits its impulses, at least in some cases, through the release of specific chemical substances at nerve endings.[11]

3. *Biology of one-celled organisms*

The importance of biochemical control of cellular activity was recognized not only from considerations of chemical mechanisms controlling growth, regulation, heredity and other complex functions in many-celled organisms. It also became known from studies of one-celled organisms, especially protozoa and bacteria. Biologists were well aware that one-celled organisms are not necessarily simple cells because of being single cells. They recognized an amoeba, for instance, as in some ways very complicated since it can perform within one cell the various functions that are divided up among very different kinds of cells in many-celled organisms. However, since many one-celled organisms do not undergo complicated processes of progressive differentiation and since they multiply by simple division, they provide populations in which multiplication and reproduction can be studied in the absence of differentiation.

Furthermore, the techniques which medical bacteriologists had devised to grow disease-producing bacteria for clinical identification were readily modified to enable physiologists to study, by accurate quantitative procedures, which particular substances bacteria required for their nutrition and their growth.

Bacteriologists made a primary move towards recognition of the fundamental similarity of biochemical processes within organisms when they proved that bacteria require for growth some of the very same vitamins that experts had shown to be essential for the nutrition of many-celled animals and man. Bacteria had been shown to be able to live under a greater variety of chemical and physical environments than any other organism, some of them even in the complete absence of oxygen. When bacteriologists, studying their life processes, proved further that no matter what substances bacteria required for their nutriment, they all stored and expended energy by the same fundamental molecular mechanism as that utilized by all other organisms, they took another important step towards the concept of the biochemical unity of organisms which was to dominate so strikingly the biology of the middle years of the century.

III. THE NATURE AND ORIGIN OF LIVING MATTER

1. *Biochemical unity of organisms*

Thus studies which had begun with strictly biological interests converged by the middle of the century towards chemical studies which covered widely divergent groups of organisms. Breeding experiments, microscopic studies of cells, and chemical investigations of nucleic acids, for instance, all pointed to

the fact that DNA acts as the hereditary material in viruses, in bacteria and in many-celled organisms. Likewise, studies on human nutrition and on bacterial growth showed that vitamins are necessary for the life of one-celled organisms and of man.

In the 1930s direct stimulus to biochemical interpretations of cellular differentiation and interaction came from the work of Joseph Needham (1900–) who focused attention on a particular class of compounds known as steroids —complex molecules, chemically closely related to each other—which he thought might be responsible for a number of processes related to growth, differentiation and reproduction. Some biologists at that time showed that the hormones responsible for the sexual characteristics of male and female vertebrates belonged to this class of compounds, and others demonstrated that the application of coal-tar products containing steroids could cause cancer if repeatedly applied to the skin of animals. Embryologists showed that some of the agents causing induction were steroids which also caused cancer when applied to the skin. Although it was later shown that a number of agents beside steroids can cause cancer and the steroids are not the only inducing substances in embryos, Needham's emphasis on the varied actions of this one group of compounds was among the important factors spurring the development of the concept of the biochemical unity of organisms.

Before biologists could focus their interest on biochemistry, however, they had first to develop more refined concepts than had been held in the nineteenth century concerning the nature of the living substance itself. The biologists of the nineteenth century defined protoplasm as the living substance, but by the end of the century had modified this concept. Late nineteenth-century physiologists and their followers in the twentieth century described the living system which constitutes cells as a colloidal system of the utmost complexity, and they learned many details of its physical and chemical properties. They studied the salts dissolved in it, its acidity or alkalinity, its electrical and its osmotic properties, its surface tension, and its dynamic relations to its surroundings in terms of physics and chemistry. In the twentieth century the use of the word protoplasm became an historical anachronism.[12]

Physiologists during the twentieth century studied the role of water, of the dissolved salts, ions, free radicals and electrons which participate in the life processes. They also showed that the substances known in the nineteenth century as essential foods in a balanced human diet are necessary constituents of all cells and are involved in the processes of molecular break-down and build-up whereby the cells obtain and use the energy for living.

Advances in organic chemistry during the nineteenth century had permitted chemists to obtain some knowledge of the structure of the complex molecules of proteins, fats and carbohydrates. The biologists of the twentieth century, through improved physical instrumentation, were able to learn much more of the structure of these compounds and the processes in which they are involved.

Particular progress was made in the study of the physical and chemical structure of protein molecules. In some cases the arrangement of their components was ascertained through X-ray diffraction studies; the contraction of a muscle fibre was shown, for instance, to depend on the change of shape of the protein molecule myosin. In addition, chemists and biochemists learned much of the chemical nature of proteins. This was important since the specific constitution of the protein molecule was supposed to be responsible for many of the highly selective properties of biological processes: for enzyme reactions, for instance, and for antibody-antigen reactions studied by immunology.

There was considerable evidence pointing to the fact that variety in the form and constitution of the protein molecule was responsible for much of the variety which distinguishes either one organism or its part from another, or one process within an organism from another. The biochemists contributed to an understanding of the basis of this variety when they were able to identify over twenty of the different amino-acids which are the components of proteins. Chemists who measured the molecular weight of proteins showed that the molecule might contain thousands of amino-acids; and biochemists believed that the various possible combinations of over twenty amino-acids and their various specific arrangements to form proteins might suffice to explain the bewildering diversity of living organisms and of vital processes. Some of them made an analogy to the number of words that might be made by different combinations of twenty letters forming an alphabet.

While organic chemists and biochemists of the late nineteenth and early twentieth century had postulated many processes whereby some of these various organic substances might be broken down in the organism and utilized in the production of energy for living, twentieth-century biochemists went far beyond them in gaining an exact understanding of the mechanisms involved. A number of lines of thought, starting out from widely divergent outlooks, contributed to the elucidation of the interrelated processes whereby energy in the cell is made available for the life processes in a mechanism common to all cells studied.

Otto Warburg (1883–   ), in the early years of the twentieth century, began the studies on the internal respiration of the cell for which he received the Nobel prize in 1931. In demonstrating that a change in combining capacity of the iron portion of an intracellular enzyme is responsible for oxygen transport within cells, he destroyed the old notion that foodstuffs are 'burned' in the organism by direct combination with molecular oxygen. Comparative biochemists found that the iron-bearing enzymes he studied, later called cytochromes, are present in all cells. From his time on, through the middle of the twentieth century, the nature of the oxidative energy-giving processes was a key problem investigated by biochemists.

Louis Pasteur (1822–95), in the 1850s, had been interested in the processes of fermentation by which cells are able to utilize energy for carrying on the life processes in the absence of oxygen. Warburg also was interested in fermenta-

tion; but the fact that the reactions occurring in fermentation and in true respiration are intimately allied, as part and parcel of the same general system of chemical reactions, was learned only as the outcome of entirely different series of studies.

Increased knowledge of enzyme action and structure, plus facilitation of the study of the transformation of one substance to another through the use of radioactive isotopes, permitted biochemists in the twentieth century to postulate a highly complicated system of interrelated chemical processes whereby carbohydrate is oxidized to produce energy, both in fermentation and respiration, through the combined action of Warburg's enzymes and of many others. The existence of a great many of the postulated enzymes, intermediate substances, and steps in the reaction was experimentally verified. The most important result of these investigations was the demonstration that the essential agent in the storage, transfer and release of energy within cells is a chemical bond holding together some of the atoms of a molecule called adenosine triphosphate, ATP for short, which is involved in the oxidation of glucose. ATP was later proved to be a principal provider of energy for all living processes in all organisms.

Biochemists discovered that a number of the vitamins and some of the hormones participated in this complex chemical system; they showed by using radioactive isotopes that the breakdown and synthesis of fats and proteins were also part of it. It was one phase of this series of reactions that was postulated as localized in a particular part of mitochondria. The proof of the universality of action of ATP in a system involving the breakdown and synthesis of the fundamental chemicals of the cell contributed strongly to the concept of biochemical unity of organisms, and was one more important step towards amplification of the evolution doctrine through the demonstration that all organisms share common biochemical mechanisms.

The study of ATP, however, involved only the investigation of energy transfer and utilization within the confines of the cell, not the ultimate mechanism by which energy is transferred from the environment into the cell. Different studies were performed to analyse photosynthesis, the process in plants by which all energy for life, originating in the sun, is transmitted to organisms which cannot create their own energy, but can only transform that which they receive from the sun.

Scientists had recognized the interdependence of plants and animals long before the nineteenth century, with respect to some of the life processes. Biologists of the nineteenth and twentieth centuries worked out in considerable detail the turnover of oxygen and of carbon and of nitrogen as exchanged between organisms, living and dead, and the soil and the waters and the atmosphere, in great cycles of synthesis and of generation and decay in which all plants, animals and bacteria participate.

Photosynthesis was known during the nineteenth century to involve the utilization by plants of carbon dioxide and water, and the production of oxy-

gen; and it was known during the nineteenth century that by using the energy of sunlight plants are able to form carbohydrates. The exact methods by which the photosynthetic process is accomplished in plants were vigorously investigated during the twentieth century. Plant physiologists showed that, in the presence of added vitamins and enzymes, the chloroplasts, and even their parts, the grana, which contain the green substance chlorophyll—the primary agent in photosynthesis—can carry out the process when isolated from the cell. Many aspects of the long and complicated system of chemical processes whereby plants break down carbon dioxide and water to form oxygen and carbohydrate became known. But by the end of the 1950s the precise method by which light-energy is converted to chemical energy still remained to be discovered. Thus biologists still had before them the challenge of learning to understand the primary and essential first step in the formation of the basically important carbohydrate molecule which, through its energy-providing properties, together with ATP, furnishes all living organisms with their potential for living and evolving.

2. *The origin of life*

Pasteur in the nineteenth century showed that life is not spontaneously generated under the conditions currently prevailing on our planet. It has been a propensity, however, of biologists for centuries to speculate on the possibility of synthesizing or creating life. Goethe, when he wrote *Faust*, had Faust's apprentice Wagner make a homunculus in a little vial, in the antique alchemical manner, and had him say, 'What used to be organized we can now crystallize'. Extension of the evolutionary concept to include conjectures as to the origin of the solar system and the earth before life arose allowed twentieth-century biologists to speculate in a new way about the origin of life on the earth. Thought in this direction was greatly stimulated by the publication of a book entitled *The Origin of Life on the Earth* by Alexander Oparin (1894–) in 1936.

Many theories were expressed during subsequent years as to the origin of organic compounds from inorganic ones; as to the origin of amino-acids and their first syntheses into proteins; as to the origin of photosynthesis to provide energy for life; as to the origin of the self-duplicating molecule DNA and its possible significance as a forerunner of living organisms. These were all based on what could be surmised of the physical and chemical state of the earth and its atmosphere at the time that life was supposed to have arisen, and were all formulated, as indeed were all concepts of biological energetics by the middle of the twentieth century, in the light of the second law of thermodynamics.

Some biologists in the twentieth century tried to duplicate some of the postulated processes in the laboratory. One investigator, by applying an electric spark, synthesized amino-acids from methane (marsh gas) and ammonia in an atmosphere of water vapour. Another, through the application of heat, produced complex molecules called polypeptides, building blocks of proteins,

from amino-acids. A third synthesized DNA outside the cell, only however in the presence of pre-existing DNA from the cell used as a primer in the reaction. Proteins themselves were not synthesized, nor was DNA in the absence of provided DNA.

Biologists were well aware that the performance in the laboratory of a few of the suggested steps by which life might originally have come into being was far from the creation of an organism in the sense that Faust's apprentice crystallized his little man. The experiments that were performed were, however, long steps forward. Biologists agreed that under certain conditions life would have originated on earth, and that once these conditions were changed it was unlikely to do so again as its precursors would be utilized and destroyed by existing organisms. The significance of the twentieth-century speculations concerning the origin of life was that they pointed up the degree to which the evolution concept had been extended to include the inanimate as well as the animate universe in a single interrelated whole. Thus, both new understanding of the similarity of biochemical pathways through which all organisms utilize energy for life, and growing knowledge of the basically similar chemical processes by which they all carry out self-propagating and change in the genetic sense, led twentieth-century biologists to a far deeper appreciation than had been formerly possible of the significance of the kinship of evolving organisms to each other and also of their relations to their simultaneously evolving environment.

NOTES TO CHAPTER XIII

1. The concept and theory of 'protoplasm', Academician Ivan Malek points out, were first formulated by the great Czech physiologist J. E. Purkyne (Purkinje) (1787–1869). He was one of the founders of cell theory.

2. To state that genes are responsible for the production of specific enzymes, writes Professor Ignat Emanuilov, it is necessary to proceed from the evidence that they do indeed exist and that they are subject to increase. But M. Demerec writes in his article 'What is a gene? Twenty years later' (*The American Naturalist*, 1955, Vol. 89, No. 844): 'up to the present time there do not exist any means, whether optical, physical, or chemical, for direct study of the gene'.

   From what is said on pages 359–60 it follows that the gene has now been replaced by the molecule DNA, which is stated to be responsible for the self-reproduction of living matter and for heredity. But the leading American geneticist C. C. Lindegren, in his article 'The Stability of the Gene', *Science* (1956), criticizes the theory of the gene. At the Tenth International Geneticists' Congress at Montreal, Canada (1958), in his paper, 'The Recombination of Complex Loops in the Yeast Saccharomyces', he states that one allele can be transformed into a completely different one through contact with maltose—and consequently not through the medium of DNA. In this case, we are told, the specific changes are carried out by specific substrates, and not by DNA. These examples show that representatives of the school of formal genetics themselves criticize the theory of the gene and attempt to substitute for it the molecule DNA, advancing its claims as the unique bearer of heredity.

3. It appears necessary to add, Doctor of Biological Sciences P. Henckel points out, that the harmony of the chromosome theory of heredity is undermined by recognition of the existence of plasmagenes, i.e. by the facts of transmission of hereditary characteristics through the protoplasm of the egg. Mendelian laws do not operate in the case of inter-specific or more distant hybridization, or of vegetative reproduction.

4. It should be stressed, Doctor of Biological Sciences P. Henckel persists, that the racists of Hitlerite Germany, in studying the mechanism of human heredity, not only drew reactionary anti-humane conclusions, but actually elaborated a whole system of measures of coercion aimed at 'improving' the so-called 'German race'.

5. Professor Ignat Emanuilov points out: The authors err in their statement that Weismann's theory was universally accepted during the first half of the twentieth century, and that only in the 1930's there appeared an opposed view regarding the inheritance of acquired characters, which for some time became the official doctrine of biologists in the Soviet Union. Already in 1907–9 the Bulgarian biologist M. Popov, in a number of experimental works, refuted Weismann's theory, and in particular the propositions that chromatin is the unique and exclusive bearer of heredity. 'Eibildung bei Paludina Vivipara und Chromidien bei Paludina und Hielix', *Arch. für mikr. Anat. und Entw. Geschichte*, Vol. 70 (1907), pp. 1–89); he showed that tetraploid chromosomes, which Weismann considered to be a specific feature of germ cells, are in certain circumstances to be found in somatic cells as well ('Über das Vorhandensein von Tetradenchromosomen in den Leberzellen von Paludina vivipara', *Biol. Ctrbl.*, Vol. 28 (1908) No. 17; pp. 555–87); that there are no physiological differences between germ and somatic cells, and that the processes of development and maturation of germ cells are common to all cells of the body ('Experimentelle Zellstudien', *Arch. Zellforschung*, Vol. I, No. 273 (1908); Vol. III, No. 1–2 (1909); Vol. IV, No. 1 (1909)).

6. Sir Julian Huxley calls attention to the fact that the process of 'genetic assimilation', discovered by C. H. Waddington, simulates the inheritance of the effects of environmental agencies, but actually depends on the selection of genetic variants which happen to favour changes in this direction.

7. Professor Vittorio Marcozzi finds the Author-Editors lacking in this chapter in consideration for the importance of Divine plan and Divine intervention, of the distinction between man and the rest of nature, or of what he calls the 'philosophical aspect'. Thus he asserts that 'some biologists maintain that evolution cannot be explained in terms of mutations and selection. Others, however, admit the validity of this mechanistic explanation in the field of micro-evolution, though they consider it incapable of explaining macro-evolution.' He states that 'some of the best psychologists' regard the view that bees 'might have evolved the powers both to make abstractions and to symbolize them' as 'anthropomorphic'. He is willing to apply the term 'consciousness' to animals as well as to man only in 'analogical senses'. To the statement of the Author-Editors that 'some biologists have considered the specifically human mental capacities for intelligence, imagination and conceptual thinking to represent the highest achievement of evolution' (page 370), he remarks that 'the problem here is not merely biological but predominantly philosophical'. When the Author-Editors discuss 'our knowledge of the chemical and physical aspects of life and of the structure of living matter', the commentator denies that this knowledge solves 'the problem of the nature of life. For this problem also possesses a philosophical aspect'. And where the Author-Editors discuss the origin and evolution of life, he states that this process 'cannot be explained simply by the play of accidental factors'. In raising these objections, Professor Marcozzi expresses the Catholic view that scientific problems are to be seen within the framework of belief in the power of a personal God and freedom of the human will.

A quite opposite view of the relations between science and religion is held by Sir Julian Huxley, for whom the findings of science themselves provide the terms in which religion for modern men must be formulated. According to Huxley: 'The supernatural hypothesis . . . appears to have reached the limits of its usefulness as an interpretation of the universe and of human destiny, and as a satisfactory basis for religion. It is no longer adequate to deal with the phenomena, as revealed by the advance of knowledge and discovery. . . .' He continues:

'Twentieth-century man, it is clear, needs a new organ for dealing with destiny, a new system of religious beliefs and attitudes adapted to the new situation in which his societies now have to exist, including the new knowledge which they have discovered and amassed. The radically new feature of the present situation may perhaps be stated thus: Earlier religions and belief-systems were largely adaptations to cope with man's ignorance and fears, with the result that they came to concern themselves primarily with stability of attitude. But the need today is for a belief-system adapted to cope with his knowledge and his creative possibilities; and this implies the capacity to meet and to inspire change. In other words, the primary function of earlier systems was of necessity to maintain social and spiritual morale in face of the unknown: and this they accomplished with a considerable measure of success. But the primary function of any system today must be to utilize all available knowledge in giving guidance and encouragement for the continuing adventure of human development' (*Knowledge, Morality and Destiny*, New York, 1960, pp. 257, 260). Huxley finds the answer in what he calls 'Evolutionary Humanism'.

For further discussion of the subject consult the following:

Theodosius Dobzhansky, *Mankind Evolving* (New Haven, 1962).
Sir Julian Huxley, *Religion Without Revelation* (New York, 1927; rev. ed., 1957).
Bernard Rensch, *Evolution Above the Species Level* (New York, 1960).
C. H. Waddington, *The Ethical Animal* (New York, 1960).

8. In connection with achievements in ecology, writes Imre Törö, Professor of Histology and Embryology, mention should also be made of biocoenosis, which established the methodology of future research in the natural sciences. So far as limnology is concerned, it is essential to refer to the existence of an important branch of modern biology, 'production biology' (a term coined by Hungarian hydrobiologists). It is concerned with research work that serves to increase the productivity of certain natural complexes such as lakes and forests, by examining geological factors, flora and fauna, and the relationships between them, and so to assist in the development of the economy and planned improvement of living standards.

9. Doctor of Biological Sciences P. Henckel points out that at this point mention should be made of the research carried out by I. I. Ivanov on the theory and technology of artificial insemination of mammals. It is widely used today in livestock-breeding.

10. Estimating the Section 'Animal Hormones' Academician Ivan Malek writes: The definition given here of hormones, and the description of their role in the life of an organism, are incomplete. It should be added that:

(1) At the present time hormones are known that are formed, not in particular glands, but in cells having other functions.

(2) Hormones exert an influence on other parts of the body, and their co-ordination of various processes.

(3) Among the functions subject to the action of hormones in invertebrates (insects, crustacea, amoeba, molluscs, and worms) that should be mentioned are growth and metamorphosis, which are two of the most important and best studied.

(4) Marked analogies have been discovered between the hormone system of vertebrates and that of the best studied groups of invertebrates (insects and crustacea).

In some cases something more than mere analogy is involved. This shows that the system of internal secretion is just as common and essential to animals as the nervous system, digestive system, etc.

11. Doctor of Biological Sciences P. Henckel points out that very little is said here about hormones in vertebrates. Mention should be made of the dependence of secondary sexual characteristics on hormones of the sex glands and experimental sex changes—of the work of Pezard, M. M. Zavadovsky, Witschi, and others. Neurosecretion, as a particular type of chemical interrelation, writes Academician Ivan Malek, has recently been described and carefully evaluated by the scientists E. and B. Schrarrer (1945–54). They describe it as an inner secretory function of certain nerve fibres, connected with the migration of granules of secretory substance from the axis cylinder (axon) of these cells to the spot where they are dissolved into the blood-stream.

At the present time neurosecretion is known to be a characteristic of all the main species

of animals. In all of them it plays a role as an intermediary between the nervous system, charaterized by short but instantaneously arising interrelations and by responsiveness to external impulses, and the endocrine system, as a means of regulation that functions slowly, over a protracted period of time.

12. It appears necessary to add, writes Doctor of Biological Science P. Henckel, that the concept of the protoplasm as a static (microscopic or submicroscopic) entity was undermined at the beginning of the twentieth century by the experiments of A. G. Gurvich. He showed that intensive centrifugation of the eggs of amphibia and echinodermata, producing stratigraphy of the ooplasm, does not prevent mitotic division of the nucleus and granulation of the egg on account of the restitution of the ooplasm. In the 1930s Gurvich developed a 'physiological theory of the protoplasm', which he considered to be a complex of non-equiponderant molecular constellations sustained by exothermal chemical reactions of the metabolism.

CHAPTER XIV

FOOD AND AGRICULTURE

I. INTRODUCTION

THE interplay between advances in the biological sciences and their application to the promotion and preservation of life was, if anything, even closer and more immediate than was the case with developments in the physical sciences and their application to the control over material resources.

The world-wide concern with the promotion of agriculture and the improvement of health led to a tendency to put new knowledge to work as rapidly as possible to improve crops, save lives or prevent disease. In most countries the promotion of new knowledge of agriculture was undertaken as a positive government responsibility, and there was a vigorous exchange of information as knowledge flowed from the scientific laboratory and as it came back in the results of practical experiment in the field. The medical profession was eager for the new tools which advancing biological knowledge could supply and the results of medical experience and tests in practice constantly flowed back to the biologist, to provide him with data for his further research. Like the alert physician, the scientific-minded twentieth-century farmer was continually extending the range of knowledge through testing and experiment.

The application of the biological sciences, moreover, was generally less hedged about by barriers to the free flow of technical information than was sometimes the case in the physical sciences, where trade secrets, patents and considerations of military security stood in the way of the pooling of knowledge. With few exceptions agriculture and medicine were both open books, and the institutions related to them were oriented toward complete sharing of tested knowledge as it emerged.

New knowledge arising from the biological sciences had an immediacy to the lives of people which much of the knowledge of the physical sciences lacked. The modern individual could use a telephone, listen to a radio, ride in an aeroplane, turn an electric switch or drive a car with little or no knowledge of any of the scientific principles involved. Somebody else could do the scientific knowing and thinking for him. But the ordinary individual had to know at least a little of the principles upon which his own health practices depended, and some elementary ideas relating to nutrition. It was usually the farmer himself, and not a remote production manager, who had to make observations and decisions involving an understanding of some of the biological principles relating to growth and genetics.

The results of the application of physical science were more spectacular,

and these appeared to be the technological changes which most greatly transformed the life of mankind during these years. Yet the application of the biological sciences may well have brought a more profound revolution in outlook and have been more responsible for the incorporation of a scientific point of view into the minds of broad segments of mankind.

Application of scientific knowledge to the production of food during the twentieth century, and to its preservation and distribution, enhanced the capacity of the earth to feed its people and reduced the proportion of the population required in agriculture and fishing in order to produce food for all. These developments were most marked in the countries which combined high population density with advanced scientific development, such as western Europe and Japan, in the labour-scarce countries, especially the USA, Canada, New Zealand and Australia, and in the USSR which reconstructed its agriculture with the application of scientific techniques. The scientific approach to human nutrition focused world attention on nutritional needs and led to measures designed to bring protective foods to vulnerable groups in the population, to modify food habits and to redirect food production.

Yet although increases in agricultural productivity kept pace with productivity in industry in areas of most advanced agriculture, and even outstripped it during the second quarter of the century in the USA, for the world as a whole productivity in agriculture remained relatively low.

During the first half of the twentieth century the gap in level of living widened as between the two-thirds of the world's people that worked the land and the one-third that depended on industry and related activities. This situation led the Director of Agriculture of the United Nations Food and Agriculture Organization (FAO) to characterize agriculture at mid-century as a 'depressed industry' and to observe, 'it is science and technology which form the basic pattern of modern human society, and if agriculture lags behind in its application, it will lag behind in the social and economic status of those occupied in it'.*

Destructive farming, grazing and lumbering practices in many parts of the world, moreover, resulted in serious loss of soil productivity through erosion, depletion and drought, destroyed wild life and greatly reduced areas remaining in a natural state. Such practices reflected carelessness with respect to abundant land resources in some areas and pressure of population in others; where new techniques were applied without regard for the ecological balance, they too could have serious effects.

As these threats to the agricultural base came to be recognized, they aroused a counter-movement for conservation of soil and forest resources and measures for soil improvement designed to check the forces of destruction and to build up the productivity of poor or depleted land.

During the twentieth century the majority of the world's people continued

* F. T. Wahlen, *Address to the 8th Session of the FAO Conference* (1955).

to be engaged in agriculture, as had been the situation since time immemorial. But a marked decline in the proportion of the population so engaged had already set in by the opening of the century, not only in the industrial countries of western Europe which depended on the agricultural resources of the Americas and Australasia for much of their grain and meat, but in these food-supplying regions as well. Throughout the nineteenth century, and in spite of the settlement of vast new lands, the proportion of the labour force of the United States engaged in agriculture had steadily declined; in 1900 it stood at only 37·5 per cent.

In the first half of the twentieth century the application of technology to agriculture sharply divided the countries of advanced agriculture from those which continued to follow ancient ways and widened the gulf between the traditional agricultural villager and the farmer in industrially developed countries. Only where agriculture was itself transformed by technology did the farmer share in and become part of the modern age. As he became a user of new knowledge, whether as a New Zealand cattle raiser, an American maize grower, a Dutch dairyman, the manager of a Soviet collective farm or member of an Israeli *kibbutz*, he entered the main stream of twentieth century life. In these countries agriculture and industry advanced hand in hand; industry was the basis of much new agricultural technology, while the presence of opportunities for employment in industry drew surplus labour from the land and created conditions which favoured measures to raise the productivity of those who remained.

The account of the application of new knowledge in the field of agriculture during these years must therefore be an account of agriculture in the advanced agricultural countries, notably the United States, Canada, New Zealand and Australia where productivity per worker in agriculture was highest; in Holland, Denmark and Japan which achieved high yields per acre; and in the USSR where the conversion of peasant farming to scientific agriculture by means of collectivization brought major improvements, though at mid-century rates of production were still well below those of the most advanced countries. And since institutional factors affected the application of knowledge to agriculture, it is necessary to consider such matters as land tenure, credit, the provision of information, and public measures to affect the economics of agriculture, as these facilitated technical advance or had the effect of reinforcing traditional methods.

Agricultural production during the twentieth century was carried on within the types of farm units traditional to different areas, or those created by more or less radical social changes during these years. In western Europe, North America and Australasia the unit was the family farm; large-scale plantations, cattle ranches and 'factories in the fields', as well as tiny holdings, were only minor elements. In these areas it was the owner-cultivator providing his own capital, labour and managerial skill who was the main agent for the application of scientific knowledge to agriculture, aided by research, in-

formation, technical advice and credit provided by government and co-operative agencies.

In eastern Europe, much of South America and most of Asia, most land was held in large estates worked by peasants, either as farm labourers or as holders of small plots under various forms of tenure, or it was divided into very small holdings worked independently. If agricultural technology reached these areas it was through the large landowner, for the peasants did not have access to new knowledge or the means to apply it. Only as major political and social changes broke down the system of *latifundia* did the agricultural populations in these regions share the new knowledge and its application. This was even more true of the traditional agricultural units of tribal Africa.

The USSR following the October revolution, and especially after the inauguration of the first five-year plan, converted the system of peasant agriculture on large estates which had existed under the tsars into a system of large socialist units. The people's democracies of eastern Europe took steps in the same direction in the decade after the second world war, while the Chinese People's Republic organized the peasants into agricultural communes.

Soviet state farms, *sovkozi*, which came to produce about a quarter of the agricultural output of the Soviet Union though numbering less than 10 per cent of all farms, served as examples, demonstrating the application of new agricultural techniques. Collective farms, *kolkhozi*, were unions of small peasants formed to conduct large-scale production on the basis of co-operative ownership of the means of production and the joint labour of members. Both state and collective farms were very large operations, state farms in the 1950s averaging as much as 25,000 acres and running up to 375,000 acres, while collective farms averaged around 5,000 acres and ran up to more than 60,000 acres. They were in marked contrast to the farms producing for market in the USA which averaged less than 350 acres. The large size enabled each farm to have its own agronomist, agricultural engineer, veterinary surgeon or other specialists, as well as central barns and storage facilities. Until the late 1950s, however, all machinery was supplied through state-operated machine-tractor stations.

The workers on state farms and the peasant members of collectives, numbering less than 100 households on the smaller units and more than 500 on the larger and averaging between 200 and 300 in most regions, composed one or more villages on each farm. With the food produced by each family on the small plot adjacent to its house, and a portion of the crop set aside annually for capital improvements, each farm was largely a self-sustaining community, with its own school, social centre, health service and other facilities. These were the units through which the fruits of scientific knowledge, supplied by the state, were applied to agriculture throughout the Soviet Union and the countries which adopted similar systems of socialized production.

During the first decade of the century efforts to increase yields and improve

the quality of major crops through better knowledge of soils and the use of fertilizers and of improved strains were intensified in European countries and North America. The great period of exploitation of virgin land in the western hemisphere and Australasia was past. Though some new land was brought into cultivation, this was largely marginal grassland converted to grain culture through new techniques of dry farming. It had become apparent that major gains would have to be achieved on lands already in use.

The first world war stimulated food production and the development of agricultural technology, especially in the transatlantic areas undamaged by war, and laid the basis for a marked increase in agricultural productivity in the years between the wars. The use of improved types of farm tractors spread with great rapidity in North America after 1920, not only reducing the labour involved in farm operations but releasing for food crops land formerly required to support draught animals. In the Soviet Union tractors were introduced as a key element in the collectivization of Russian agriculture and its reconstitution on a scientific and technological basis. European countries whose production had been curtailed by war recovered and soon exceeded former levels, except in parts of eastern Europe where changes in land tenure reduced the output of some former cash crops. Although new lands were not a major source of expanded production in this period, more northerly lands were brought under cultivation in the USSR as new strains of grain were developed, some new lands were opened up in Argentina and Brazil, Italy and Holland reclaimed land through drainage, and arid lands were cultivated by means of irrigation in the United States, as well as in the Middle East and India.

The principal bases for the greatly increased yields in these years, measured both in yields per acre, which were high in Europe, and production per agricultural worker, most noteworthy in North America, were: the spread of mechanization, the application of genetics to the development of more productive and disease-resistant strains, the increased use of scientifically designed fertilizers, the use of improved fungicides and insecticides, improved methods of tillage, and scientific farm management. The production of livestock, milk and eggs was correspondingly increased by improvements in animal nutrition, selective breeding and disease control.

Prior to the second world war all of these developments were confined almost entirely to the prosperous, industrialized segments of the world, chiefly North America, Europe, Australasia, the USSR and Japan. It was the industrial potential of these countries, in fact, which made possible the widespread application of new knowledge to agriculture. Without a vigorous chemical industry to produce a large volume of each new insecticide, weed-killer or fertilizer, and implement producers to turn out agricultural equipment in quantity, the tremendous gains in agricultural productivity during these years could not have been made.

Elsewhere there was little change in ancient, traditional agricultural

methods and in the availability of food, although some European countries initiated a small amount of agricultural research and development in areas under their colonial administration and a start in the same direction was made in the western hemisphere through the establishment of the Inter-American Institute of Agricultural Sciences in Costa Rica. Famine remained endemic in Asia and struck in China and India several times during the period. In Africa the traditional subsistence agricultural economy was undermined in some areas by the drawing off of men to the mines or by shifts from subsistence to cash crops.

There thus developed in the inter-war years, outside the self-contained economy of the USSR, a world pattern of countries where agriculture had become so productive that markets were glutted with surpluses and others with low rates of production whose people lived at precarious levels far below the average consumer in the food-rich areas. The problem of agricultural surpluses in the countries of high technology was intensified in the 1930s by the world-wide economic depression which reduced both domestic and world markets, and by the tariff walls erected by European countries seeking to make themselves more self-dependent against the threat of a second world war. Countries experiencing such surpluses instituted various measures to protect farmers' income from the effects of glutted markets. The problem of endemic hunger in many parts of the world, however, was not yet a matter of active world concern.

In the mid-thirties a new element entered the picture, which had major influence on the direction of developments in the following years—the focusing of attention on the problem of nutrition. The new science of human nutrition, which had been developing since the early years of the century, was brought into public consciousness and public policy by a series of events: the League of Nations appointed a Mixed Committee on Nutrition in 1935; two publications attracted wide attention, Sir John Boyd Orr's *Food, Health and Income* (1936) and the United States Department of Agriculture's *Diets at Four Levels of Nutritive Value and Cost* (1933); the results of the dietary surveys undertaken in several countries revealed the presence of extensive under-nutrition and malnutrition even in countries with surplus food supplies.

During the second world war nutrition became the basis of agricultural policy, most notably in Germany, Japan, Great Britain and Switzerland, where nutritionally oriented production and rationing sustained the population under prolonged wartime stress and, in the case of Britain, even improved the nutritional level of segments of the population. After the war, nutritional considerations entered into the agricultural policies of both food-rich and food-poor countries.

In the decade after the war the position of the industrialized, scientific farmer in Europe, America and the USSR was consolidated. The scientific approach was applied with increasing effectiveness to problems of farm management, over and beyond the separate component factors affecting

production. The agricultural entrepreneur who operated an economic-sized farm with the tools of modern science and technology, and likewise the members of collective farms, became as much a part of the modern world as their industrial counterparts.

This decade also saw widespread organized efforts to place in the hands of the peoples of underdeveloped areas the means to reconstruct their traditional food production, to reduce the backlog of malnutrition and to provide a basis for sustaining the coming generations. Technical assistance programmes of FAO, the United Nations and its other specialized agencies, the Organization of American States, individual countries and private welfare groups supplemented the national efforts of developing countries to improve their agricultural methods and raise their nutritional levels. In the people's republics of eastern Europe and China, this objective was sought with the technical co-operation of the USSR by means of the reconstruction of their agricultural economies mainly on a collective basis.

At mid-century world attention was focused on the problem of how to achieve and maintain a balance between food production and consumption at a level of health and vigour. Both in the areas of individual farming and in those of socialized agriculture it was widely recognized that this did not depend upon agriculture alone, but upon many aspects of economic life: industrial development to employ unused and unneeded agricultural workers, the provision of cheap and abundant power, the effective preservation, transport, storage and distribution of agricultural and food products, and the means of financing the highly capitalized modern farming operations. It depended on access by farmers to the kind of education and continuing sources of information which would enable them to understand and apply the growing body of scientific knowledge in the field.

The establishment of the United Nations Food and Agricultural Organization in 1945 provided an international organ for world food development. Its studies and reports and its programme of work were directed toward the application of agricultural technology on a world scale to the welfare of the world's farmers, to the effective elimination of hunger and to the promotion of good nutrition. Its creation as the first of the United Nations agencies reflected the sense of urgency with which the countries of the world had come to view the problems of food and agriculture by mid-century.

II. AGRICULTURE

1. *Development of agricultural technology*

Agricultural problems varied sharply in different areas but in one form or another they were present everywhere. For the underfed half of the world's population, especially in Asia, food production even in the years after the second world war was lagging behind in the race with population increase,

though by mid-century the rate of lag was falling. In areas of advanced agricultural development, such as Denmark and Holland, scientific farming lay at the basis of the nation's prosperity and must be maintained. Countries such as Britain which had largely abandoned agriculture in favour of industry turned to scientific farming for national security.

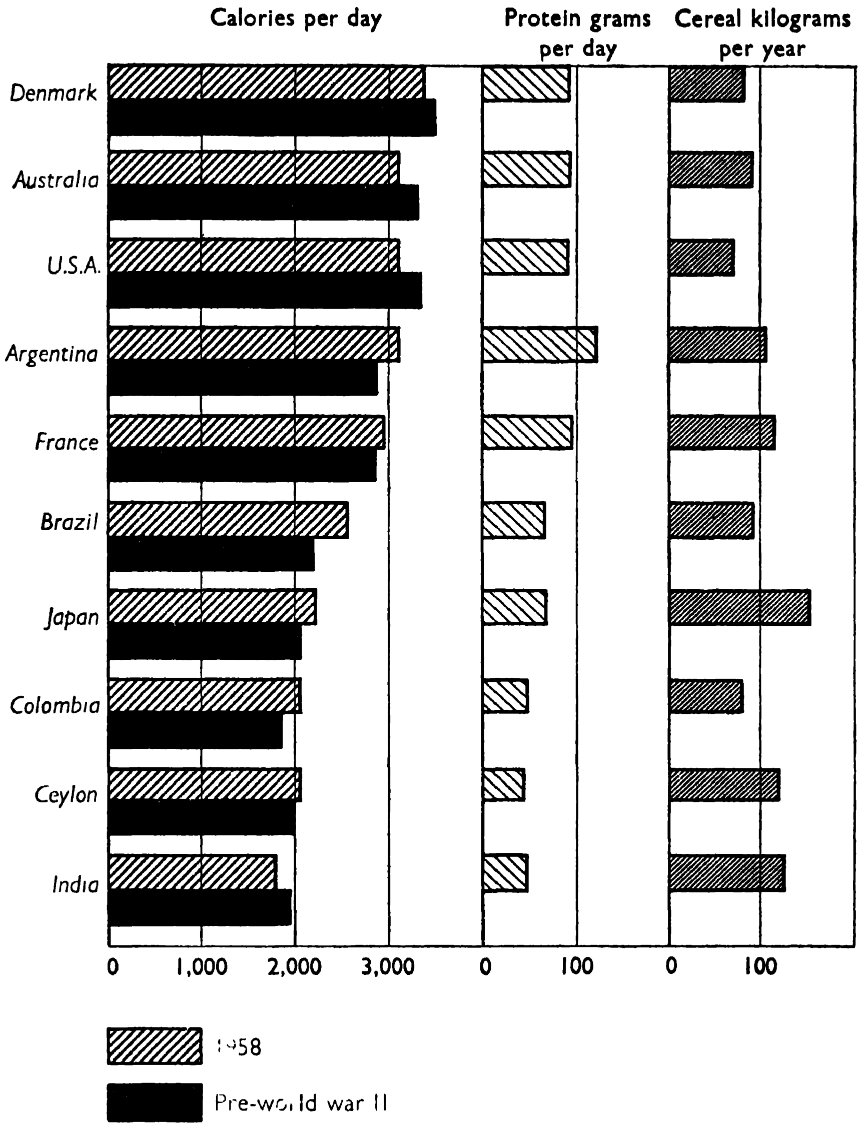


CHART XV. Food Consumption *per capita:* Calories, Protein, Cereal, 1958 and pre-World War II in Selected Countries.

Source: *U.N. Statistical Yearbook,* 1960.

For the new lands of the Americas and Australasia, where extensive farming of virgin soil could no longer bring the rich returns of the previous century, science and technology had brought highly productive agriculture, but had left unsolved many problems of economic adjustment. The USSR, confident that its state and collective farms offered the most effective means of raising productivity, was still striving to bring the gains in agriculture up to those in industry. Israel's efforts to bring fertility to barren lands in the Middle East was one of the most determined of the widespread efforts to make arid lands productive. Africa's potentialities under modern methods of cultivation were only beginning to be explored at mid-century.

For mankind as a whole, the critical questions were: how could the productive capacity of the earth be conserved and enhanced rather than destroyed; how could the world's capacity for food production be developed and used to sustain the world's people; and what limits, even under favourable conditions of conservation, exploitation and distribution, would the earth's resources place on the optimum size of the world's rapidly growing population?

(*a*) *Agricultural technology at opening of the twentieth century.* At the beginning of the century a balanced system of productive agriculture existed in northern Europe and in some other areas of the temperate zone to which the European system of crop rotation had been extended. This system, developed in the late eighteenth and nineteenth centuries, involved the rotation of row crops, such as wheat, with grasses and legumes and the use of animal manure and chemical fertilizer. It had raised north European wheat yields from 6–10 bushels per acre, where they had stood from Roman times to the end of the eighteenth century, to 20–30 bushels by 1900, with corresponding increases in other crops and substantial increases in the production of milk and meat. It provided the framework for further increases of 30–50 per cent in European yields during the first half of the twentieth century, in spite of the setbacks resulting from two destructive wars. It also laid the basis for improvements which greatly increased productivity per farm worker. By mid-century it was still the only system of permanent agriculture that produced continually high yields while maintaining the fertility and integrity of the soil.

In the new lands of the western hemisphere and the south Pacific the foundation was being laid for a shift from extensive cultivation that exploited the plentiful soil to scientific methods of conserving soil and increasing production. In the United States agricultural experiment stations had been established in each state and a national soil survey to study and map the character of the soil had been inaugurated in 1899.

In Japan at the opening of the century a system of intensive rice cultivation on irrigated land was beginning to show the higher yields that were to make the Japanese system an example for neighbouring countries of Asia.

During the twentieth century many types of new knowledge revolutionized

agricultural production in some areas and revealed immense possibilities for the rest of the world: knowledge of soils—their properties, structure and response to different methods of treatment; of genetics which made it possible to improve the strains of plants and animals; of nutrition which revealed the needs of plants, animals and humans and the means of satisfying these needs; of the physiology of plants, animals and humans which indicated both how to provide conditions favourable to healthy growth and how to destroy noxious weeds and pests and control disease; of chemistry as it permitted the development of countless fertilizers, pesticides and drugs; of engineering which produced mechanical equipment to supplement and replace human and animal labour.

From time to time a single development appeared to be of overriding importance, such as the use of DDT to free areas of potentially productive land from the malarial mosquito or the spectacular increase in yields from hybrid maize, or the saving of whole herds through elimination of rinderpest in Africa and Asia. But generally the agricultural achievements of the twentieth century were the result of a combination of interrelated measures. In the final analysis they depended on the conversion of the traditional cultivator who practised a routine craft into one who used new knowledge as it became available, evaluated its results according to scientific principles, and exercised sound judgment and skilful management at each step in the farming process.

(*b*) *Soil science and plant nutrition.* Basic to twentieth-century agricultural progress was the growing knowledge of the world's soils, and how to make and keep them productive. Soil science was not new; it had been inaugurated with the establishment of the Rothamsted Experimental Station in England in 1843 and with major Russian efforts in the 1870s to explore and analyse the Russian land-mass with its great range of climate and topography.

At the opening of the twentieth century the prevailing concept of soil was that which had been put forward by the German chemist, Justus von Liebig (1803–73), who regarded the soil as a sort of bank from which plants drew the chemical nutrients which had been placed there. Study and application focused on soil chemistry and the use of fertilizers. As the work of Russian scientists became better known, especially that of V. V. Dokuchayev (1846–1903) and his associates, the concept of soil shifted from that of a storage vault into which nutritious chemicals were inserted and withdrawn, to that of an immensely complex structure alive with micro-organisms and composed of many interacting layers whose character was determined by the original rock from which they were formed, time of formation, climate, vegetation and the configuration of the land. Soil science had to confront thousands of distinct kinds of soils, categorized by Russian soil scientists under a few main heads, and to determine how best to manage each.

The most pressing problem of soil management in many areas was how to check the destructive erosion which took an annual toll of millions of acres,

especially in new lands where farmers 'mined' the soil. A general erosion survey in the United States in 1934 estimated that two-thirds of the land had lost more than a quarter of the original topsoil—some had lost all—and that half of the land in cultivation was being progressively depleted by the practices then in use. Books with such titles as *Our Plundered Planet* (by Fairfield Osborn, Boston, 1948) dramatized the problem created by open cultivation of steep hillsides, overgrazing and cutting of forests which destroyed the grass and trees that had held the soil and retained moisture, and the ploughing up of the dry prairies.

From the 1930s onward, prevention of erosion became a major defensive component in programmes for agricultural development, as many governments undertook intensive efforts to teach their farmers such soil conservation practices as contour-ploughing and maintenance of grass cover, and embarked on construction projects for upstream dams, reforestation of denuded hillsides, restrictions on overgrazing, and the planting of shelter belts to check wind and dust storms. By mid-century these steps had reduced but had not eliminated the erosion threat. The United States had not yet fully reversed the downward trend in soil fertility, while major losses continued in South America, Africa and elsewhere. In irrigated areas land was still being lost because of salt accumulation much faster than preventive and restorative measures and reclamation could counteract the process.

With progress in soil science, soil conservation shifted from the negative effort to prevent waste to positive attention to soil management.

Recognizing that many of the arable soils of the world are made better by good farming than they were in their natural state, soil scientists insisted that low fertility of the soil could no longer be accepted as automatically ruling out certain areas or condemning them to low productivity. They expressed the view that the technical possibilities for expanding the world's food supplies were very great, noting that 'the evidence from soil science leads to the belief that, given favourable social and institutional environments, the world has abundant resources for a dependable food supply under efficient soil conservation practices, based upon the soils that we have and the results being obtained by a fraction of the world's cultivators'.*

The techniques developed by soil scientists were based on the analysis of the entire profile of a particular soil to several feet in depth, noting its physical properties and chemical and bacterial content in relation to its location and climatic environment. Some forty major types of soil were identified, with subdivisions running into the thousands, and these were used for the construction of detailed soil maps and as a basis for advice to farmers as to how best to use their particular land. By mid-century the detailed mapping of the soils of the United States and of the USSR, which had been in process in both countries for fifty years, was far from complete. Elsewhere extensive

* Charles E. Kellogg, *Address before the Fifth International Congress of Soil Science* (Leopoldville, Belgian Congo, August 1954).

soil mapping had been carried out in Canada, Australia and New Zealand; considerable mapping had been done in Hungary, Portugal and Belgium, as well as in Great Britain and the Netherlands; soil mapping had been begun in parts of Africa, notably Southern Rhodesia, the Belgian Congo and British and French colonial areas. But nowhere had soils been fully mapped in detail.

Farmers of the temperate zones profited more during this period from the developments of soil science than did those of the tropics, although the latter had even greater need of a scientific basis for soil management under the rigours of tropical climates. Only a beginning had been made in systematic work on these soils at institutes of tropical agriculture in India, Indonesia, the Belgian Congo and Puerto Rico. Under the technical assistance programmes of the FAO, the US and the Colombo plan, soil scientists were sent to some thirty countries during the ten years following the second world war.

The study of soils was paralleled by a growing knowledge of plant nutrition. Attention was first focused on the major nutrients needed for plant growth—nitrate, phosphorous and potassium—and the conditions under which they were found in the soil in a form which plants could use. Chemical or organic fertilizers were designed to provide these in the balance which the particular soil and the particular plants required. The effect of soil acidity on specific plants had long been recognized and the liming of acid soils was a generally accepted practice.

Even with adequate supplies of these basic substances, however, crops showed signs of malnutrition and set scientists searching for the causes. These investigations revealed that a variety of minerals such as iron, boron, manganese, copper, zinc, nickel, cobalt, are needed in minute quantities, and that the addition of these 'trace' elements to soils which were deficient in one or another mineral could bring spectacular results, such as those achieved on what had been thought to be uncultivable lands in Australia. The science of plant nutrition was carried to the point where plants could be grown in water, supplied with a complete set of chemical nutrients.

Biologists, meantime, identified the role played by various microorganisms as they affect the nature of the soil and the ability of plants to derive nourishment from it. The discovery in 1888 that bacteria which grow on the roots of legumes enable these plants to take nitrogen from the air and then convert it into usable form in the soil had enhanced the importance of legumes in systems of crop rotation and led to much work on the development of types of legumes suitable for various climates, soils and purposes. Further understanding of the processes by which the decomposition of organic matter in the soil contributes to its chemical content and to its structure made it possible to use manures and composts more effectively. Some people in fact insisted on the exclusive use of organic material rather than chemical fertilizers to maintain soil fertility. Their view was not widely accepted in its most extreme form, but their insistence on the importance of

soil structure and the presence of humus was a reminder that continuous productivity of the soil depends on more than the known array of inorganic chemical nutrients.

Emphasis on soil structure also led to studies of methods of ploughing and cultivating the soil other than those which happened to be traditional to a particular area, and resulted in the design of implements suited to the depth or manner of treatment needed. Chemists investigated the possibility of treating the structure of the soil chemically and experimented with chemicals that appeared to have some capacity to loosen clay soils and maintain the new structure for a period of years.

When careful studies of the most effective ways to use a wide variety of fertilizers were coupled with progressive knowledge of plant nutrition, they revealed that yields could be greatly increased if far larger quantities of chemicals were used than had been thought to be effective, and if they were applied at the right time, in properly prepared soil and in the most usable form. In the 1950s farmers in the United States were using more than five times as much fertilizer as they had used only twenty years before, and were applying much of it with the precision which agricultural science dictated.

Extensive use of chemical fertilizers was confined almost wholly to the agriculturally advanced countries. It was negligible in Asia, except Japan, in the Near East, except Egypt, in Africa and in most of Latin America. Commenting in 1954, the FAO reported that 'taking the world as a whole, we have only begun to use the potentialities inherent in the chemical fertilizer industry'.*

(*c*) *Plant genetics and growth.* While soil science and research into plant nutrition laid a basis for increased yields, plant geneticists were hard at work seeking improved strains of wheat, rice, maize and other major crops. In each of the agriculturally advanced countries a continual process of selection and testing singled out the strains best adapted for the particular climate, soil, moisture, resistance to disease, or other factor needed in a particular area. In the US in 1955, 70 per cent of the cultivated land was planted to improved varieties that had not been in existence twenty years before. Among major crops the proportion of new varieties was even higher, including 80 per cent of the wheat, 86 per cent of the maize, 92 per cent of the oats, 95 per cent of the cotton, and 98 per cent of the soya beans.

Although the results of plant breeding to secure better stocks penetrated more thoroughly in North America than in most other areas, improved strains of basic crops were developed, tested, multiplied, distributed and planted in western Europe, Japan, Egypt, the USSR and in some parts of Argentina, Brazil and Mexico. In the years after the second world war,

* W. H. Pawley and others (FAO), *Possibilities for Increasing the Supply of Food and Agricultural Products by Exploitation of New Areas and Increasing Yields*, paper presented to World Population Conference (Rome, 1954).

scientific plant breeding as a relatively low-cost means of increasing food supplies was taking hold in the newly developing countries, especially in parts of India, Indonesia, Ceylon and Formosa.

Plants were bred for many different factors, not only high yields but adaptation to longer or shorter growing periods, or to colder or warmer, wetter or drier conditions. Plants were bred with a view to ease of harvesting by machinery, as for example types of cotton that grew high on sturdy stalks and ripened simultaneously for harvesting by mechanical cotton pickers. From the first attempt in the US in 1895 to develop a strain of cotton resistant to a soil-borne wilt disease, crops threatened with extinction were saved by the development of disease-resistant varieties. These included, among others, wheat and other grains resistant to rust, sugar beets, sugar cane, tobacco and lettuce. For nearly every vegetable, strains were developed that withstood the most threatening disease to which they were subject. Development in the USSR of sunflower strains resistant to rust and mildew made this the major source of vegetable oil in the Soviet Union, after its production had been abandoned in the United States in favour of soya beans because of susceptibility to disease.

Breeding for specific factors in the environment had dramatic effects in extending the areas which could be cultivated. Marquis wheat, for example, based on a cross between a European and an Indian variety, opened up much of western Canada as a result of its earliness and yield. Breeding for resistance to drought greatly extended the limits of the wheat belt in Australia and North America. Efforts, especially in Canada and the USSR, to breed earlier maturing varieties of various crops continued to push northward the frontiers of cultivation and offered possibilities for bringing into use the lands of the northern zone.

Selective breeding and crossing of strains according to Mendelian principles in order to reinforce or introduce desired characteristics accounted for most of the advances attributable to plant breeding, but the most spectacular results were obtained through in-breeding and hybridization. Initial experiments in developing pure strains of maize by in-breeding in order to eliminate recessive characteristics, and then crossing these pure strains, were undertaken in the early years of the century by scientists engaged in genetics research. Their discovery that the first generation of certain hybrids showed 'hybrid vigour' vastly superior to that of either parent led to the development of hybrid maize and then to extension of the procedure to other species.

The practical implication of these experiments, which permitted much greater control of quality than open crossing, were quickly recognized and tested out in a number of agricultural experiment stations in the United States. By the 1920s supplies of hybrid seed were becoming available and American farmers were beginning to learn of its new possibilities. Once they started to use hybrid maize, they adopted it rapidly. In 1933 only one-tenth of 1 per cent (·001) of maize acreage in the US was planted with hybrid

seed. Ten years later 51 per cent was so planted, and after another ten years, 87 per cent.

Following this experience, plant breeders extended the principle of inbreeding and hybridization to other out-crossing species and produced a number of successful hybrid strains of vegetables suitable to particular areas; animal breeders successfully applied the same principles to poultry. By mid-century the use of hybrid seed was still largely confined to North America and Europe, but was spreading as strains adapted to new localities were found, while the less complex process of seed selection, crossing, and multiplication of desirable strains was under way in many more of the agricultural regions of the world.

High yields from hybrid seed did not depend on the seed alone but on the combined effect of seed, fertilizer and method of tillage, for each of these factors reinforced the others and multiplied their effect. Hybrid maize showed only about 20 per cent higher yields when planted in the same manner as other maize; but experiments with methods of tillage showed that it could be planted much closer together and that it could make use of much more fertilizer. When scientifically developed methods of tillage and generous application of appropriate fertilizers were combined with superior hybrid seed, the result was not just a 20 per cent increase but a doubling and tripling of production, or even more.

Appraising the potentialities for increased food production, the FAO in 1954 concluded:

'Selection, which involves choosing the best of what already exists, and hybridization, which involves creation of new genetic combinations, offer tremendous opportunities for further increasing agricultural production. In the more advanced countries, further progress will probably come mainly from hybridization. But in underdeveloped countries . . . the scope for improvement by systematic collection, testing, purification and concentration on a limited number of varieties is usually substantial. The production of new varieties opens up great possibilities which have hardly been explored in most underdeveloped countries'.*

Beyond selective breeding and hybridization, plant scientists discovered ways to produce mutations in the genetic stock, by means of radiation and by the application of chemicals. Among the latter, colchicine was found to induce doubling of the chromosomes, thereby altering the character and generally enlarging the size of the plant and permitting new genetic combinations. Although these treatments were not used, prior to the middle of the century, to affect importantly the major food crops, their use in the breeding of flowers indicated latent possibilities. The growing understanding of the nature of genes and how they may be affected, moreover, presaged further development of controlled mutations in the future.

* W. H. Pawley and others, *op. cit.*

Discoveries with respect to hormones and chemicals which regulate growth in plants offered still another medium through which to control plant development. These regulators of plant growth proved effective in delaying or advancing the time of blossoming, as for example in enabling pineapple growers to have plants flowering and ripening in every month of the year instead of all at once; they could be used to keep fruit from dropping before it was fully ripe, or for inducing the formation of roots so that more plants and trees could be grown from cuttings; introduced into a plant's system, they could promote or distort its development or destroy it. By mid-century, the use of these plant regulators had revolutionized the process of weed control and had opened up new possibilities for adapting plant life to man's needs.

By the same period the availability of radioactive isotopes enormously aided research into plant nutrition and development. They made it possible to trace in detail the manner in which plants absorb and use nutrients and other products and to detect the effects of any substances with which plants come in contact. On the basis of such careful studies of plant physiology, ever more precise and effective methods of cultivation could be designed.

(*d*) *Plant diseases, weeds and pests.* Positive measures to produce good plants, suitable to many environments and requirements, were accompanied by systematic attacks on the elements which interfere with plant growth or survival—disease, weeds, insects and other pests.

The battle against plant diseases was fully joined during the twentieth century with the same vigour shown in the campaign for human and animal health. While plant geneticists were breeding strains resistant to the most menacing diseases, chemists produced a wide variety of substances with which to spray or dust plants, treat seeds before planting, and purify the soil to eliminate soilborne infections. The struggle against plant diseases was a continual one, as the very measures which provided better conditions for plant growth generally improved the environment for the organisms which attacked plants. On the other hand, treatment designed to eliminate noxious or disease-bearing entities from the soil could destroy needed organisms. Prior to the second world war a few basic chemicals were used to combat fungus and virus diseases. During and after the war a multitude of new organic chemicals proved vastly more effective than those in earlier use. In this period, too, antibiotics which controlled disease in human beings and animals were applied with effectiveness to plants as well.

New chemicals and other measures to control insect pests and eradicate weeds were even more revolutionary than those for the control of plant diseases. DDT, developed during the second world war and in use around the world by mid-century, was greeted as a miracle because it was the first substance to destroy a wide range of insects both by contact and when eaten, and it retained its lethal properties for a long time. Originally discovered by German and Swiss dye firms seeking chemical dyes that would deter moths

from eating woollen cloths, this product was immediately applied to military uses such as the protection of troops against typhus and malaria through elimination of body lice and malarial mosquitoes, and was tested out as an agricultural pesticide. When it was made generally available to farmers at the close of the war, it quickly became the most widely used ingredient of sprays and dusts for many purposes. Some of its achievements in the field of agriculture were spectacular. It helped to double the yield of potatoes in the US by control of insects, and to bring under control many of the most destructive of the orchard and forest pests.

DDT and other insecticides, however, had serious limitations, for they often killed many predators of the pests as well as pests themselves, they destroyed other desirable organisms, they resulted in the survival of mutants which were resistant to the chemicals, and they were often injurious to man.

The effectiveness of DDT and other new chemicals was enhanced by simultaneous improvements in methods of applying them, notably the development of the aerosol. Sprays or dusts delivered with ordinary apparatus quickly fell to the ground and reached only limited targets; the aerosol, a fine mist which remains suspended in the air like fog, enabled much smaller quantities to reach the insects in a given area more thoroughly. While the aerosol was most useful for the disinfestation of an enclosed space, such as an aeroplane cabin or a barn, it also permitted the production of spray fogs which could be carried by air currents to envelop whole areas.

Mass attacks, meantime, were conducted by means of the aeroplane. Dusting of forest areas against destructive moths, of swampy regions against mosquitoes, and of fields and pastures against many specific pests not only protected the crops of individual farmers, but set up regional barriers to the spread of insects from one farm to another. Where such wholesale attacks were undertaken, there appeared to be good prospects for success in the unremitting war which all farmers must wage on insects and other pests.

DDT was by no means the only chemical to show marked success against pests; and fortunately so, for as soon as the insects susceptible to DDT poisoning were killed off, the hardy mutants which appeared to be immune to its effect multiplied. This called for new research to find products which the new strain of insects could not withstand, and for new techniques of application such as alternate use of different chemicals to catch the strains immune to one type. Extensive research was undertaken in an effort to determine the physiological mechanisms involved in order to be able to combat the resistant strains.

Pesticide research looked for poisons which could be economically administered, as well as be effective. This led to the finding of chemicals which could be fed to the plants themselves along with the fertilizer, making the plants toxic to the insects which tried to eat them. While this reduced the application of fertilizer and pesticide to a single operation, it could be used only when the result did not make the plant also toxic to its human or

animal consumer. Other devices included the fumigation or poisoning of the soil to eliminate diseases, destructive organisms such as nematodes, the grubs of destructive worms, and weed seeds. Chemicals were even found which first killed weed seeds, nematodes and other plant enemies in the soil and subsequently broke down into substances which served as fertilizer at the time that the crop was planted.

Biological forces as well as chemicals were called into play in the attack on pests. Observing the balance in nature, scientists looked for the natural enemies of the insect pests in order to utilize them as allies. The possibilities of this approach had been demonstrated before the turn of the century, for example in the identification and importation into California in 1889 of the Australian ladybug to control the Icerya scale that was infesting the citrus trees.

The quest for such parasites or other natural enemies became a routine part of pest-control research. Biological warfare against insects and larger animal menaces also took the form of the spreading of disease. The extremely destructive Japanese beetle was brought under control by infesting the soil containing the beetle grubs with a milky disease. The rabbit disease, myxamatosis, brought the Australian rabbit population down to 10–20 per cent of its previous numbers within a few years, in spite of the survival of disease-resistant animals. Such diseases were, however, dangerous tools, for they could get out of hand, be transported to other areas, destroy more than was intended or by removing a predator permit another species to multiply to excess.

Weeds too were subjected to attack by chemical and biological means. Here the revolutionary discovery was that substances which regulate plant growth can be used to destroy weeds more completely and more selectively than chemicals which merely destroy foliage in order to deprive the plant of its oxygen. The most widely used of the new systemic poisons, 2-4D, when taken into a plant's system in sufficient quantity eventually destroys its whole structure. Since this substance affects only broad leafed plants (dicotyledons) and does not injure grains or grasses (monocotyledons) it can be used in the cultivation of maize, small grains and sugar cane. Similar substances and various cell-destroying chemicals were sought and found to work selectively in cotton fields and elsewhere. Insects were also used to attack certain weeds, among them the cactus moth and other insects used in Australia in the 1920s to clear many millions of acres of the prickly pear which had been spreading at the rate of a million acres a year.

The use of chemicals to control plant disease, insect pests and weeds was still by mid-century confined almost wholly to North America, western Europe, Australia and New Zealand, USSR, Japan and Egypt. On the situation at this time the FAO noted that 'the gap between knowledge and practice is probably greater than ever before, owing to particularly rapid scientific progress in recent years'.*

* W. H. Pawley and others, *op. cit.*

(*e*) *Livestock.* The application of science to the improvement of livestock followed the same general lines as for field crops: the application of genetic knowledge to animal breeding, knowledge of animal nutrition, the control of animal diseases and parasites, and the provision of a favourable environment for the animal's growth.

Selective breeding of livestock was not new in the twentieth century. The enclosure movement in England in the sixteenth century had facilitated the improvement of herds and the standardization of lines of sheep, while the breeding of horses was a traditional and highly skilled art among Arab peoples. In the twentieth century scientific breeding of livestock was based on studies of such factors as milk production by the progeny of proven sires, the rate at which animals put on weight in relation to the amount which they were fed, the configuration of meat animals, the quality of wool of sheep or the laying habits of hens.

Work along these lines in Europe, USSR, North America and Australasia bore fruit by the middle of the twentieth century in superior animals of every sort. By maintaining careful records of performance animal breeders, especially in the Netherlands, Denmark, UK, New Zealand, Switzerland and USA built up a body of data on which very careful selection of the desired factors could be made. The organization of dairy improvement associations in the United States using proven sires resulted in herds with an average milk production twice that of other dairy herds in that country. Even more spectacular results were achieved in Holland which at mid-century had the highest milk production per cow of any country in the world.

Improvement of both dairy and meat herds was greatly facilitated by development of means of artificial insemination. In the United States organizations for artificial insemination were set up in every county where dairy farms were numerous. There, in the USSR and in Europe, artificial insemination was used to produce thousands of progeny from a single selected sire. Methods of preserving the semen through quick freezing made it possible to reach herds at greater distances from the sires and thus to extend the influence of selective breeding to a much wider area. Strains of livestock that showed resistance to disease were also developed, such as Texas cattle crossed with Zebu which were resistant to cattle tick fever.

The results of livestock research were slower to become apparent and to be applied than in the case of plants because of the longer time between generations and the smaller number of progeny. By mid-century they were largely confined to the developed agricultural countries. It was apparent, moreover, that the countries which lacked a background of years of livestock research could not simply import into areas of difficult climatic and disease conditions stock which had proved to be highly productive in its native habitat. Beginnings had been made in these areas with the slow process of studying and selecting indigenous stock adapted to local conditions and cross-breeding it with animals from outside to develop superior local strains.

Development of animal nutrition paralleled animal breeding and included improvement of pastures, the use of balanced prepared feeds and provision of the vitamins that were as important to animals as to man. Work on animal and human nutrition went side by side, discoveries in one contributing to the other. Of special importance was the discovery of vitamin B12, known as the animal protein factor, which supplied most of the substances which vegetable protein failed to provide in animal feed or human food. In temperate areas of Europe, America, Australia, New Zealand and South Africa, superior grasses and legumes, together with fertilization of pastures, strip grazing, the mowing of fodder to avoid waste from trampling, and the use of grass silage enabled improved pastures to support many more animals.

Elimination of animal diseases, especially those which could strike with epidemic force, was of the utmost importance. Among the diseases brought under control were the foot-and-mouth disease of cattle, driven out of the United States in 1929, rapidly being brought under control through international efforts in the American republics and the object of intensive international control measures in Europe; swine fever against which pigs were protected by immunization, a treatment which had become virtually universal in the United States by mid-century; testing for and elimination of foci of infection of tuberculosis and brucellosis (contagious abortion) in cattle and goats, especially important because these diseases could be transmitted to humans in the milk; and several of the diseases, particularly Newcastle's disease and coccidiosis, which devastated flocks of poultry and impeded large scale raising of poultry until they were brought under control. The elimination of rinderpest in Africa and Asia, undertaken with the help of the FAO, was the indispensable first step toward improved livestock in these areas. The one animal disease of major proportions still remaining to be conquered at mid-century was that produced by the tsetse fly in Africa, but beginnings were being made in the breeding of cattle resistant to this disease, and extensive aerial spraying had cleared the tsetse fly from large areas.

Elimination of internal parasites, though less dramatic than control of epidemic diseases, made the difference between stunted growth and fast-gaining animals. Improved drugs were discovered and then mixed into the animals' normal feed to keep herds and flocks continually free of debilitating infestations. The accidental discovery that animals throve on feed that contained residues from the preparation of antibiotics opened yet another area of research with respect to animal feeding. The combination of highly nutritious feed, adequate supply of vitamins, control of parasites and the use of antibiotics led to such increases in animal growth that many pigs, beef cattle and chickens were going to market at lower ages and much higher weights than had been the case in the past. These improvements made it possible for animals to put on as much as 20 per cent more weight with the same amount of feed. The total effect of improved breeding, improved nutrition and the control of animal diseases increased the average production of livestock

per breeding unit in the United States between 1920 and 1955 by 67 per cent.

Attention was also paid to the habits of animals in order to determine the environment in which they did best. Studies showed that animals ate more, gained weight faster, gave more milk or laid more eggs under specific conditions of light, water, heat, cold—even music. By controlling environmental conditions, farmers secured more meat, milk and eggs from a given herd or flock.

The difference between the developed and the less developed countries with respect to animal husbandry was perhaps even more marked than in the production of field crops. In most of the underdeveloped countries the livestock, fed on unimproved pasture or without the attempt to provide balanced feed, ate little more than enough to keep it alive, and did not consume much which could be converted into body growth and the making of meat, milk or eggs.

(*f*) *Farm mechanization.* While twentieth-century agriculture owed its greatest increase in yields to the application of biological and chemical knowledge, farm mechanization played a major role in North America, it was a cornerstone of the agricultural programme of the USSR, and after the second world war it became an essential part of farm development in Europe. Mechanical equipment drawn by animal power had been developed in the nineteenth century for such heavy and difficult processes as reaping, threshing and cultivating, and many new implements were developed in the twentieth century which could be drawn either by animals or by motor power. It was the substitution of tractors for animal power on the farms, however, which constituted the major element in twentieth-century farm mechanization; in addition, lorries and jeeps replaced animal-drawn vehicles for farm chores and transport to market.

The first tractors were large machines, suitable only for use on large acreages such as the huge wheatfields of the American prairies or the Russian steppes. Their cost was high, their operation clumsy, and they were beyond the reach of individual farmers who had operated their farms with a team of horses or bullocks. In the 1920s small tractors designed to have the flexibility of the work animal and be suitable for use on the small farm came on to the market, and their use spread widely from the 1930s onwards until animal power was driven from most of the small as well as the large North American farms.

Substitution of tractor for animal power not only increased the amount of work which the farmer could do but released much land from cultivation of feed crops for the work stock and made this land available for the production of food. By reducing the time required for sowing and harvesting, it lengthened the growing season and made possible the use of marginal land where the frost-free period was short or rainfall periodic. The tractor also provided the farmer with motor power which could do many things besides drag agri-

cultural implements, and enabled him to perform quickly and alone many farm tasks which had required much time and labour.

In the years after the second world war, the number of tractors in use in Europe tripled as part of the effort to increase food production, and was especially high in the British Isles. The use of tractors had already reached substantial proportions in Australia, New Zealand and the USSR and was beginning to spread to Latin America. By mid-century, however, it had only begun to reach the Near and Far East. A rough picture of the extent of farm mechanization may be gained from the number of arable hectares per tractor, although the large, almost completely mechanized grain farms which made up a large proportion of the farming of North America, the USSR and Australia are hardly comparable to the smaller mixed farms more characteristic of western Europe and the rice cultivation of much of Asia. The ratios were roughly as follows:*

WORLD TRACTOR NUMBERS BY REGIONS[a]

Region	1938–39	1953	*Arable area per tractor* 1953 (*hectares*)[d]
Europe	275,000	1,414,000	104
North America	1,695,000	4,650,000	50
Latin America	35,000	189,000	470
Near East	5,000	52,000	1,200
Far East	—	20,000	8,500
Australasia	57,000	211,000	100
USSR[b]	524,000	969,000	230
TOTAL[c]	2,590,000	7,505,000	130

(*a*) Tractors of 8 h.p. or over included. Underestimates Europe where garden tractors most numerous.
(*b*) Stated in terms of tractor units of 15 h.p.: most farm tractors exceed 15 h.p.
(*c*) Omits some small countries in Near and Far East, dependent territories, China, Union of South Africa; add *ca.* 150,000 tractors to 1953 total to include these areas.
(*d*) 100 hectares = 247 acres.

The use of mechanical equipment on farms encountered major difficulties in areas where farms were small and farm operators poor. The high initial cost limited the use of equipment to relatively well-to-do farmers, co-operative groups, individuals who specialized in doing contract work with their equipment, or to the government which established machine pools or tractor stations. Where there was an abundance of labour, as in the Asian countries, the inducement to substitute machine for hand labour was negligible. Here the main advantage in using tractor power was to do the hard tasks which could not be done with the human or animal power available. In the monsoon areas tractors could break up the hard soil before the monsoon

* FAO, *The State of Food and Agriculture, 1955* (Rome, 1955), p. 61.

rains instead of waiting for the soil to be softened by the rains, and crops could thus be planted sooner. Similarly, the use of power at harvest time made it possible to get the crop off the land quickly and to prepare the soil for a subsequent planting. Tractors were also used to condition land which needed a drastic treatment. In India for example they served to break up land which had grown up to tough grass; once broken the newly conditioned land could be maintained by farmers with their traditional tools.

Two methods were used to introduce farm mechanization where conditions were relatively unfavourable—the establishment of farm machinery centres and the designing of small machines. The tractor stations where machines could be kept in repair were general up to 1958 for the collective farms of the USSR, and government tractor pools were beginning to be maintained in such countries as Ceylon, Indonesia, Burma, Turkey, Egypt and several Latin American countries, including Peru, Brazil, Cuba and Chile. Small, relatively low-cost equipment which could be used by the owner of a small plot and which he could afford to purchase was developed particularly in Japan. Japanese rice-threshing machines, for example, could be carried by hand to small plots, assembled to the engine which could be separately transported, and could then be carried on to another field or back to the barn when threshing was completed. The motor could then be used on another small piece of equipment, such as a machine for husking the paddy. In Europe the small garden tractor served similar purposes in the hands of small farmers.

The use of machinery on the farm required not only a vigorous farm-machinery industry but someone with a knowledge of mechanics to keep it in operation and make repairs. In countries where mechanical knowledge was general, the farmer himself became a mechanic, able to keep his equipment in running order and to make minor repairs. In addition a repair service industry grew up throughout farming areas. In non-mechanized regions, however, the attempt to introduce agricultural machinery ahead of the general familiarity with mechanical processes frequently resulted in the breakdown of the machinery, in the absence of anyone to take care of or repair it, and its prompt disuse. In an effort to avoid these wasteful results in areas where mechanical knowledge was not widespread, tractor pools were used as training centres. In some areas simple farm implements were introduced before the attempt was made to adopt more complex ones; an FAO technical consultant in the Near East, for example, started by introducing an adjustable blade on a hand scythe in order to teach farmers the use of a wrench and screw bolt.

On the fully mechanized farms of North America, Australia, New Zealand and western Europe, where mechanical power and electricity were available, power was applied to ploughing, planting, cultivating, fertilizing, harvesting, animal feeding, milking, pumping irrigation water, handling and transporting products and many other operations. Machines used for harvesting sugar cane on the highly mechanized sugar fields of Hawaii replaced the laborious

process of cane cutting for thousands of workers. Aircraft were used for sowing and spraying and chemical weedkillers replaced the patient labour of men and women with hoes.

(*g*) *Farm management.* In order to use the fruits of scientific discovery through efficient farm management, the farmer of the mid-twentieth century needed to know many things: how to secure an analysis of his soil and to determine what crops and what fertilizer to use; what method of tillage was likely to give him the greatest yield; what chemicals to apply to pests and weeds and in what strengths; what amount of moisture and how best to apply it; how to feed, doctor and house his livestock; how to take care of his equipment and keep it in repair. He must be able to handle and plan the financing of the investment in the farm and its equipment and to understand markets and changes in market conditions. In short the twentieth-century farmer was called upon to understand and command the resources which science and technology had made available to him and to assume responsibility for using this knowledge with wise judgment.

Where family farms prevailed, the individual farmer not only had to master a wide range of skills but to plan intelligently, organize effectively and make decisions constantly in the light of new considerations. From being one of the most traditional of occupations, farming became one requiring the greatest alertness and readiness to change. These developments gave a great advantage to those farmers who were the most intelligent, well trained and best able to afford an experimental approach. They placed at an increasingly serious disadvantage the poor or ignorant farmer whose lands were insufficient for economic operation, who could not secure the capital to invest in improvements that would increase his yields, whose income was so low that he could not risk loss and therefore dared not try something new, or who lacked the necessary intelligence or opportunity to learn good farm management.

Where farming was carried on collectively, the main responsibility for farm management fell on the managers of state and collective farms, acting in accordance with directives provided by the state. It was thus concentrated in relatively few hands; in the USSR the total number of farms in 1958, 82,400, was less than 2 per cent the number of farms in the United States, and 4 per cent of US full-time commercial farms, although the area under crops was a third larger. Under the Soviet system of machine tractor stations where all the major equipment used by collective farms was held, management responsibility was shared by the directors of these stations, since they determined when and how the equipment would be used; after these stations were abolished in 1958 and the machinery distributed to the collective farms, full responsibility rested with the collective farm managers aided by boards composed of key members of the farm.

The change in the nature of farming had the effect of opening up an enormous gap between the scientific agriculture of the technically advanced countries and the traditional methods which generally prevailed in the rest

of the world. For countries seeking economic development, the effort to raise agricultural productivity and income could involve changes as radical as those required by industrialization.

Modernization of traditional agriculture, however, encountered severe obstacles not only in the farmers' lack of knowledge and experience but in lack of capital and especially in the excessive numbers of persons on the land. To the extent that agricultural technology was labour-saving, its introduction displaced agricultural workers; but rural people were already leaving the land in most of the underdeveloped countries more rapidly than urban employment could absorb them. The initial effect of such methods was to create further unemployment.

Mechanization of agriculture in the manner of North America, western Europe or the USSR had much less to offer these areas initially than labour-intensive methods such as those used in Japan to achieve very high yields per acre. Improved seed, improved tillage methods, use of fertilizer, better methods of weed and pest control and the adaptation of small implements all presented possibilities for raising productivity without displacing undue numbers of farm workers and with a minimum of capital outlay. These were the kinds of improvements towards which many development programmes and technical assistance projects were directed in the effort to bring the advantages of modern agricultural science to farmers in the developing regions of the world. The Chinese People's Republic used these same methods in its vast modernization programme, which relied mainly on changes in organization and farming practices to raise yields.

2. *Adaptation and dissemination of agricultural knowledge*

The development, and especially the application, of agricultural knowledge required field testing under the varied conditions of soil, climate and topography with which farmers of different areas had to deal. Although much new knowledge came to agriculture from the scientific laboratory and basic principles had general validity, such knowledge only became usable when problems of application had been worked out in appropriate settings. Individual farmers however were rarely in a position to conduct systematic experiments.

(*a*) *Agricultural research.* Agricultural experiment stations where new knowledge was tested out under local conditions therefore became a central feature of the agricultural structure in most countries. The first such stations were established in the 1840s, at Rothamsted, England, Edinburgh, Scotland and Mockern, Germany. In the last quarter of the nineteenth century a network of experiment stations was set up in the United States, especially after 1887 when federal grants were provided to all state agricultural universities which maintained stations. By the 1950s the US government, in co-operation with the states, was conducting agricultural research in some 500 research locations throughout the country.

Each of the European countries established research centres for practical agricultural study, including such famous centres as Wageningen in Holland and Svalov in Sweden. Britain set up stations in different parts of the country under a programme initiated in 1909 and greatly extended the work during the second world war; it established agricultural experiment stations throughout its possessions as part of its colonial administration. The centre established by the Dutch in Java was one of the most extensive stations for research into tropical agriculture. In Russia the broad terrain and varied climate led to extensive field studies in the nineteenth century; under the Soviet régime the Lenin Academy of Agricultural Science, established in 1929, was conducting more than 150 of its own research institutions during the 1950s, covering various branches of agricultural science, and it directed the activities of agricultural science bodies, selection centres and experimental centres throughout the USSR.

(*b*) *Agricultural education.* Actual adoption of improved methods, however, depended upon their being known and understood by the farmers, and upon the latter's attitude towards the rationalization of agriculture and their readiness to depart from practices deeply rooted in tradition, folk ways and folk wisdom. The channels of education and communication through which agricultural knowledge flowed were essential to its use.

General education as it developed in the nineteenth century was strongly urban in content and orientation, not only in Europe and North America but wherever the British or continental European systems of education spread. Agricultural content was especially lacking in Britain. By the second quarter of the twentieth century, and especially after the second world war, agricultural materials were being included in basic education for rural areas much more generally than before. This tendency reflected the educational trend toward using direct experience as a source of teaching material; school gardens or poultry-raising offered an opportunity for learning by doing. Education for adults was also built around practical problems.

Specialized agricultural schools at the secondary level began to be established by European countries in the late nineteenth century, along with other types of technical schools for children who did not continue their academic education or leave school altogether; two schools in Hungary were among the first of these establishments. By the middle of the twentieth century such technical agriculture schools were universally a part of the educational structure wherever the European educational system prevailed. At the higher education level, faculties of agriculture or special agricultural institutes also offered professional training to agronomists or agricultural engineers.

In the United States, agricultural universities were set up in each of the states in consequence of a law in 1862 which made large grants of federally owned land to the states for the support of such institutions. In the early twentieth century states began to introduce agricultural subjects into their secondary-level high schools and in 1917 the federal government provided

grants to the states for this and other vocational subjects, a noteworthy development in view of the fact that general education otherwise was wholly financed by states and localities.

Agricultural training in the USSR was greatly expanded after 1928, both at the higher and the secondary level, with the result that by 1957 the number of people with higher or secondary agricultural training who were working directly on farms was nearly 7·5 times as great as before the second world war.

Specialized agricultural institutions and special courses in regular schools provided formal channels for the transmission of agricultural knowledge. But in a field where knowledge was growing daily and its use depended on understanding and action by many thousands of independent farmers, it was not enough to provide technical instruction in schools and colleges. The new knowledge must reach the farming population directly and be accepted generally.

To meet this need a number of countries developed a distinct pattern for carrying new knowledge to the farmer and his family by means of agricultural extension services. The USA and Holland were among the countries which developed extension methods most fully and which provided models and personnel for the introduction of similar programmes elsewhere. By mid-century their methods had come to be widely accepted as a way to achieve the spread of scientific agriculture.

The US Agricultural Extension Service, established in 1913 and expanded rapidly under the stimulus of the first world war, operated through local agricultural agents who conducted demonstrations, advised farmers individually or collectively, conducted study groups or discussions, distributed literature or engaged in any form of education which would be effective among the farmers of a particular area. The programme was tied to the state agricultural universities and was supported by funds from federal and state governments and farm organizations. In the Netherlands separate extension services supported by the central government and linked to the appropriate research centre were organized for agriculture, horticulture, livestock and dairying. In the 1950s the agricultural extension service alone provided one local extension worker for every 400 farmers. In combination with a network of agricultural schools and courses at elementary, vocational and professional levels, which were attended by approximately half of all Dutch farmers, they helped to raise Dutch agriculture from a backward art at the beginning of the century to one of the most productive in the world by the 1950s. Extension services in Denmark were organized and administered by farmers' organizations with subsidies from the government.

Farm women too were encouraged through the efforts of extension home demonstration workers in the USA, Holland and elsewhere to take advantage of modern knowledge in the conduct of the farm home, in raising and preserving vegetables, in applying nutritional principles to the feeding of the family, in child care and in other aspects of family and rural life. In Canada

and Britain Women's Institutes, established during the first world war to encourage rural women to make best use of available supplies in time of scarcity, stimulated village women to learn and share techniques of cooking, preserving, gardening and poultry raising, and encouraged handicrafts and popular arts.

Informal education of farm youth was also developed in a number of countries as part of the agricultural extension programme through clubs where boys and girls learned improved farming practices for themselves by engaging in projects such as raising an animal or a special crop. Known usually as 4-H clubs, their original name in the USA, or some variant such as 5-V clubs in Venezuela or 3-C clubs in Colombia, or Young Farmers in Ceylon, they did much to give rural youth a positive orientation toward the business of farming.

The core of all extension methods in countries where farms were individually operated was personal contact with the farmer. This was accompanied and supported by meetings and study clubs, through radio, films and press, and through demonstration plots and experimental farms where the farmer could judge new methods for himself.

Agricultural extension was unique at the time of its inauguration, for it meant carrying a public service directly to the people. As the idea of the welfare state emerged, the methods which the extension services had developed for dealing with people on their own terms and enlisting their interest and active participation spread not only to agricultural programmes of many other countries but to activities and services in other fields. By the 1950s agricultural extension programmes or their equivalent were general in Europe; they had been introduced, frequently with US technical assistance, in a number of Latin American countries. The FAO conducted regional training centres for agricultural extension, during the single year of 1953, in Beirut for the Near East, in Peru for Latin America and with Dutch and American collaboration, in the Netherlands for Europe. Agricultural extension activities were incorporated into the community development programmes of various countries as these programmes were established, notably in India, Pakistan and the Philippines.

In the Soviet Union, the latest developments in agricultural science were disseminated from the ministry of agriculture through the ministries of the several republics to the state and collective farms, where the farm's specialist in each field was responsible for digesting technical information and passing it on to his fellow workers so that they might put the new ideas into practice on the farm. Magazines dealing with the types of production in which each farm was engaged reached the libraries in the social centres of the collective and state farms, as did magazines of special interest to rural youth. The Communist party organization conveyed to the farms information relating to the national plan and the responsibilities of the farmers for their part in carrying it out.

The adoption of improved methods of farming depended in the last analysis on the attitudes of farmers. One of the most striking examples of the re-orientation of a farming population took place in Denmark in the last quarter of the nineteenth century, where a depressed agriculture was converted, through co-operative organization, cultural revival and application of scientific knowledge, into one of the most progressive in Europe. Even in the USA, which lacked the deep-rooted traditions of older agricultural societies, practical farmers spoke scornfully of 'book farming' and it was not until the second quarter of the twentieth century that scientific farming was fully accepted; but once it took hold it was pursued with enormous vigour. In the struggles of Europeans to stay alive during the second world war and to recover agricultural productivity after the war, most of the remaining resistance or indifference to agricultural rationalization was swept away in these areas. Great Britain went so far in its agricultural legislation of 1947 as to authorize the government to take away a farmer's land if he failed to practise 'good husbandry' and this provision of the law was in fact carried out.

Farm magazines played an important part in the development of a scientific attitude among farmers. In the USA magazines addressed to the working farmer, which were among the periodical publications with the largest circulation in the country, kept news of the latest scientific developments flowing into the farm home in a form which the farmer could understand and use. In these journals the commercial suppliers of the fertilizer, equipment, insecticides and other materials on which modern farming depended described their wares in terms of their contribution to the newest agricultural practices. Their advertising in the 1950s was addressed in technical terms to farmers who were presumed to have detailed knowledge of soil chemistry, plant and animal nutrition and methods of planting and cultivation, and who were expected to make their decisions in terms of careful calculation and rational consideration of alternative practices.

Practical changes in the conditions of rural life did much to alter the farmer's outlook. Roads and motor travel broke down his isolation; rural electrification not only provided power for farm tasks but conveniences for farm living—lights, electrically pumped water, household appliances; radio and television brought the outside world into the farm home; mail-order houses and chain stores serving rural areas made the same wide range of goods available to rural as to urban consumers; accessible motion pictures brought the same kind of entertainment to country as to town; improved rural schools and health services brought comparable facilities within the reach of farm families. By mid-century the farmer in countries of advanced agriculture enjoyed amenities similar to those of the town, and was exposed to many of the same currents which shaped the outlook of the urban dweller.

In all these ways a milieu for advanced agriculture was created, both in areas of individual and of socialized farming, in which the farmer was no longer governed by tradition and folk wisdom, but was brought into the

stream of rational scientific thought. The most fundamental contrast between countries of advanced agriculture and those where agriculture followed traditional methods was in the atmosphere within which the farm operation was carried on.

Modernization of farming in underdeveloped areas involved a change in attitudes and milieu even more than changes of specific agricultural practices. It was towards this objective that much of the technical assistance in agriculture and many of the community development programmes of the 1950s were directed, as were also the radical changes of the socialist economies.

3. *Organization of agricultural production*

The application of scientific knowledge in the field of agriculture depended on the ways in which agricultural production was organized, its legal basis and economic potentialities, as well as on the progress of agricultural research and the dissemination of new knowledge.

(*a*) *Landholding and land use.* Basic to the structure of production were the size and nature of the farming unit and the system of land tenure on which they rested. In contrast to industry whose structure was largely determined by technology, the structure of agriculture in most areas was traditional.

With the exception of commercially organized plantations, which made up a small proportion of the world's farms, the size of the farm unit and the manner in which its lands were distributed were the product of historical accident, family size, inheritance laws or other factors which took little account of the optimum unit for a particular type of farming. The rationale for existing structures, if any could be recognized, was related to quite different technological conditions from those which developed during the twentieth century. The fragmented holdings in much of Europe, for example, had come down from the three-field system of cultivation of the mediaeval manor or village community, further subdivided by inheritance according to the principles of the Napoleonic Code; the 160-acre American farm had been acquired originally under the Homestead Act of 1862 which enabled settlers to claim homesteads of this size in hitherto unsettled areas. In these circumstances the farmer made what he could of his inherited farm, whatever its size, sometimes abandoning it for city employment if the latter were available and his lands inadequate, sometimes trying to acquire additional holdings by purchase or marriage where this was possible.

Systems of tenure in many parts of the world at the opening of the twentieth century were also unfavourable to agricultural progress. In western Europe, North America and Australasia, owner-cultivators enjoyed security of title; in Britain, where tenancy was general, cultivators were protected in their tenure so long as they practised good husbandry. But in most other regions land was held in large estates worked by those who did not own.

The bulk of the land in eastern Europe and Russia and some in western Europe was in the hands of formerly feudal landlords; in Latin America it

was held in *latifundia* with many feudal characteristics, or in plantations worked by agricultural labour; it belonged to hereditary owner-rulers—sheikhs—in the Middle East; it was held by absentee landlords who collected quit-rents in India and other parts of Asia, or by operators of tea, cotton, rubber, coconut or other plantations.

In all these areas tenant cultivators had neither the means nor the incentive for improvement, for barely a subsistence income remained to them when they had satisfied their obligations to their landlords; they had no reserve out of which to make investment in fertilizer, equipment or soil-improving practices, and they had no assurance that the fruits of their extra effort would accrue to themselves; their holdings were generally too small to provide an adequate farm unit; in some areas obsolete systems of cropping were established by rigid custom or law. Absentee owners of large estates were often interested only in collecting their rents; other landlords frequently lacked the capital for modernization. Moreover, so long as they had at their disposal a plentiful supply of cheap rural labour which continued to eke out a living on the land for lack of alternative employment, there was little incentive to invest in equipment or adopt labour-saving practices.

There were of course progressive operators among the large landowners in all regions, and it was through them that new methods and new equipment were introduced into areas in India, for example, or in Latin America where the small proprietors were too small, poor or uneducated to undertake new ways. More generally, however, tenant-cultivators on large estates remained traditional in their methods and received incomes that were close to or even below the level of subsistence.

Owner-cultivators on excessively small holdings—*minifundia*—were generally to be found in the same regions where large holdings prevailed. Often they cultivated the hillier or rougher land while the large estates occupied the fertile valleys, though *minifundia* were characteristic of much irrigated rice land in the valleys of south-east Asia. Even if they had secure ownership, they had too little income, and many improved practices could not be applied to such small units. Labour-intensive practices in Japan and China, however, demonstrated the possibility of getting much more from small plots than farmers in areas such as India and Java were doing. In some places, notably parts of Latin America, south-east Asia and Africa, small farmers pursued a system of shifting cultivation, without acquiring title to the land which they cleared, cropped and then abandoned. Where systems of family tenure were traditional, as in Jamaica, British West Indies, uncertainty of title made it difficult for cultivators to take advantage of credit which was available only to those whose land titles were clear.

During the twentieth century land reform became a burning issue in many parts of the world.* By the middle of the century much land had passed out

* See Chapter XXX, Drives for Individual Freedom and Human Dignity: Peasants and farmers.

of the hands of former owners into those of the men who worked the land, and the large private landholder had become a diminishing type. The impetus for these reforms came generally from political pressures and social movements. Their effect on agricultural efficiency depended largely upon the size and organization of the resulting units in relation to the types of agriculture involved and on the technical and financial aid available to the cultivators.

Reforms directed most specifically toward agricultural improvement were those designed to consolidate fragmented holdings and to bring idle or unimproved land into cultivation by taxing it heavily, as in Britain, or exempting reclaimed land from taxation, as in Colombia, Mexico or Chile. Several European countries set up procedures for the consolidation of fragmented holdings, notably Switzerland, where the average farm in 1905 consisted of 14·3 plots and in 1950 still averaged 8·7. In France, where legislation to facilitate the consolidation of small holdings had been in effect since the close of the first world war and additional legislation which went into effect after the second world war greatly accelerated the process, the FAO reported in 1950 that half of the cultivated land was still in need of consolidation to make workable farm units. Spain, Holland, Belgium and Sweden were among the other countries adopting similar legislation. These countries had before them the unique example of Denmark which had consolidated most of its land into farms of economic size at the beginning of the nineteenth century and had prevented their subsequent break-up by law.

Where there were simply too many people on the land—the situation in many regions—measures designed to create economic farm units met insuperable difficulties. In the crowded area of western Ireland, legislation enacted in 1923 was used to a limited extent to resettle some farmers whose holdings were too small on unused land expropriated from large estates; their former lands were then added to the holdings of those who remained in the locality. But in the absence of alternative sources of employment the problem of *minifundia* remained unsolved and reforms which redistributed large holdings often left untouched the basic difficulty of insufficient land *per capita*.

Land reform movements in Latin America, eastern Europe and Asia demanded the transfer of ownership from large landlords to the tenant cultivators. The first such movement to be successful was in Mexico, where land for the peasants became a major objective of the revolution of 1910. In the course of the next thirty years about half of the cultivated land in the country was expropriated and transferred to villages under the *ejido* system traditional to the country. By this system, title to the land vested in the village and villagers received individual plots which they retained so long as they cultivated them. The reform freed the cultivators from debt-peonage to the landowners and improved the terms of employment of agricultural labour and of crop-sharing for tenants. It did not however provide peasants with economic-sized holdings or raise the level of agricultural productivity, for it

gave *ejidal* rights to those who were actually on the land, regardless of their number. By 1945 the average *ejidal* holding was close to the minimum size for subsistence and even at that a quarter of those entitled to claim land as *ejiditarios* had not received a plot. Larger plots, improved credit and additional technical assistance in later years began to overcome some of these unfavourable factors.

In eastern Europe and Russia, where the feudal system remained essentially intact at the opening of the century in spite of the abolition of serfdom, the demand for redistribution of land was strong and there were frequent peasant riots or revolts. Lenin's promise of land to the cultivators brought the support of the peasants to the October revolution and acted as a stimulus to land distribution in neighbouring areas. One of the first steps taken by the new states of eastern Europe which came into existence after the first world war was to divide up large estates and vest title in the individual peasants. These measures, however, were carried through extensively only in Czechoslovakia and partially in Yugoslavia before the reaction against the new democratic governments led to the establishment of dictatorships and a halt to reform.

After the second world war the communist governments of the east European countries moved to redistribute the land with extreme rapidity. Division of the large estates in East Germany was completed in four months, in Hungary and Rumania in ten days. These measures were designed to eliminate the surviving feudal structure rather than to establish permanent peasant proprietorship, however, and they constituted a first step toward collectivization, the aim of agricultural policy in these countries. In Yugoslavia, widespread individual ownership resulting from both the earlier and later periods of land distribution was accompanied by a trend toward co-operative farming in some areas.

In the USSR the socialist transformation of agriculture was carried out on a gigantic scale with the organization of peasant farms into collectives, and the establishment of state farms as demonstration units. In the years after 1928 these types of agricultural organization almost completely replaced the individual family farm. While the immediate effect of this unprecedented experiment in the complete economic and social reconstruction of agriculture was to reduce output for the time being, the collective structure provided the means through which knowledge of improved agricultural practices could reach the peasants and productivity could thereby be increased. The Soviet state extended technical assistance and guidance to the collective farms, supplied them with modern machinery and introduced social and cultural facilities designed to eliminate much of the difference between the way of living in villages and towns. The Soviet collectives provided a model for the people's democracies of eastern Europe, where similar programmes were applied at varying rates and in different ways according to the situation of each country.

In the years after the second world war extensive changes in landholding were carried out throughout Asia and the Middle East. The chief effect of these reforms was to remove the absentee landlord as a rent collector—as he had been, for example, under the *zamindar* and related systems in India—and to leave existing cultivators in possession, subject to direct taxation by the state. The cultivator was thus relieved of some of his burdens, which had often been very high in relation to his output, but without change in the size of his holding or conditions of cultivation.

In addition, redistribution of large holdings was inaugurated in a number of countries. Such redistribution in Japan added to the holdings of more than half of the Japanese farm families, though the size of farms which resulted remained still very small. In India voluntary gifts of land were stimulated by a follower of Gandhi, Vinoba Bhave, at first to individual farmers (*bhoodan*) and then in the late 1950s to village units for co-operative agriculture (*gramdan*). Although some millions of acres were transferred under his stimulus, this movement was far from solving the difficult land problem.

The Chinese People's Republic undertook the most drastic reorganization of agriculture attempted by any country, adopting in the course of its first ten years successive measures, first to distribute land to the peasants, then to organize them into co-operatives, and finally to convert rural communities into people's communes in which both labour and consumption were organized on a communal basis.

In the Near East some expropriation of land for distribution to landless farmers became part of the policy of all countries in the area. Turkey adopted an ambitious programme of land distribution in 1945, but in the early stage of its operation it served mainly to provide a means of resettling large numbers of Turks repatriated from Bulgaria. The Egyptian agrarian reform law of 1952 set an upper limit of 84 hectares to the amount of land which any owner could continue to hold and called for the redistribution of the remainder. Similar legislation in Lebanon, Iran, Iraq and Syria looked toward the substitution of a measure of peasant proprietorship for the large estates which characterized the region. In Iran the Shah in 1951 set an example by the distribution of some of the crown lands. Only in Israel however was ownership by cultivators the rule, either through communal groups—*kibbutzim*—and co-operatives or, less frequently, by individual proprietors.

In the countries of Latin America other than Mexico, little headway was made in modifying the *latifundia* system except in Bolivia, where a comprehensive land redistribution programme was undertaken in 1952, and in Cuba where agrarian reform followed a successful revolution in 1959. The experience of Bolivia well illustrated the difficulties in attempting to lay a basis for efficient agriculture in areas where there were too many people on the land. In an effort to prevent a further lowering in the productivity of Bolivian agriculture and to achieve a division into sufficiently large units to permit the peasants who received land to make a decent living, the land

reform law provided for the allocation of minimum-sized units, determined in relation to the quality of land and its appropriate use, and permitted the retention of somewhat larger units by those who were already using improved agricultural methods. Where there was insufficient land to provide an economic-sized unit for each cultivator then on the land, those who could not be supplied were to be resettled from the crowded highlands to the relatively undeveloped region of the lowland jungles.

It proved virtually impossible, however, to carry out this careful plan, for the peasants who were living and working on the land took possession and put such pressure on the local courts to confirm their titles that much land was subdivided into far too small plots. As for the plan to permit economic farms to operate with larger acreage, the peasants refused to accept this part of the measure; they moved on to such lands, and even the government itself was unable to hold some of the lands in its experimental farms against occupation and division by land-hungry peasants.

Similarly in Indonesia, peasants after independence occupied and destroyed forests which were essential to erosion control in their efforts to translate *merdeka*—freedom—into the possession of land.

Where large, private landholding survived, both in areas of advanced and of traditional agriculture, agricultural labour remained the most poorly paid and disadvantaged group. Wage levels in agriculture in 1950 were comparable to those in industry only in Australia and on the state farms of the USSR. Although the differential was substantially reduced between the 1930s and 1950s in most European areas, agricultural wages in the latter period were still less than half the average in industry in the USA, Italy, Japan and India, and in Mexico they were only 20 per cent of industrial wages in spite of land reform in that country. Measures to protect workers from exploitation comparable to those in industry—minimum wages, regulated hours, minimum conditions of work—were only slowly extended to agricultural workers.

In addition, plantation workers were often employed seasonally, generally for harvesting, and remained in a precarious condition for the rest of the year unless they had other sources of employment; when labour was performed by migratory workers who moved from crop to crop with the harvest season, their status might be even more insecure. A noteworthy attempt to convert plantation agriculture without losing the benefit of large scale operations was undertaken in Puerto Rico after 1942, where the lands of sugar estates in excess of a maximum of approximately 250 hectares were organized by the government into profit-sharing or 'proportional benefit' farms, operated as a unit for the benefit of the workers. Even under this system, however, the profits returned to the workers were not sufficient to carry them through the 'dead season' between harvests without other sources of income.

In many parts of the world, resettlement schemes were undertaken in an effort to take care of surplus rural populations. There were measures to

resettle poor farmers from crowded Java on other islands in the Indonesian archipelago, notably Sumatra; Italian and Spanish peasants were settled on reclaimed land, Iraqis on land brought back into cultivation in the upper Tigris-Euphrates valley, and farmers from the Andean highlands in the unsettled plains or jungles of South America. These and many other schemes sought to cope with the ever-growing problem of the landless or impoverished peasantry, whose rate of increase, mounting with the spread of measures to preserve health, exceeded the ability of urban employment to absorb the rural surplus. On the whole, however, resettlement measures received only limited support and they offered a very minor solution to the great problem of excess population on the land.

Agricultural development thus depended upon the expansion of industrial employment as much as upon trends within agriculture itself. Small industries scattered through the country were part of the economic development policies of some countries, notably India and Puerto Rico, as they had been in the industrialization of Japan. Electricity and the internal-combustion engine made such industries possible, and atomic and solar energy might make them yet more feasible when these sources of energy should become generally available. But whether through rural industries which would supplement agricultural employment or by drawing off excess farm population to industrial centres, industrial expansion was a key to enabling agriculture to yield a living to producers comparable to that provided by industry.

At mid-century the world's agriculture was a long way from a pattern of organization which would make effective use of the great and growing body of agricultural knowledge.

(*b*) *Agricultural credit.* Second only to the problem of landholding was that of agricultural credit or other sources of capital. Most aspects of improved agriculture required additional capital and intensified the farmer's perennial problem of finding the resources with which to meet his costs of production during the crop year until his income came in with the harvest. The modern farmer needed funds to invest in equipment and improved livestock and for additional fertilizers, insecticides and selected seed.

The problem of agricultural credit was a reflection of the structure of the agrarian economy; it was neither new nor limited to particular types of farming. The moneylender with a stranglehold on farmers was traditional in the agricultural countries of eastern Europe and Asia. The American farmers' political demand for cheap money had been their historic response to their position as debtors. In the USSR the credits made available to collective and state farms through the banking institution were determined by the requirements of the national economic plan and the manner in which each farm fulfilled its goals.

Regular lending agencies in the free economies, accustomed to secure themselves against risk, normally charged rates of interest which made borrowing prohibitive for all but the wealthiest farmers, and the need to make

special provisions for agricultural credit came to be recognized in a large number of countries. These took the form of co-operative credit associations, either standing alone or linked to a central credit institution maintained by the state, special agricultural banks with government support or subsidy, or direct provision of agricultural credit by the state. After the 1930s when depression pushed farmers to the wall at the very time that new technology was calling for additional capital, these facilities were greatly extended.

Even these special provisions, however, frequently failed to meet the needs of the poorer farmers. This was true in the countries of advanced agriculture such as the United States and Britain, and even more true of countries of low agricultural productivity such as most of the countries of Asia and much of Latin America. In India for example, where co-operative agricultural credit had been available for fifty years, only 3 per cent of the credit used by farmers was coming from this source in the 1950s and another 4 per cent from the state and other financial institutions; Indian cultivators continued to depend on private moneylenders, landlords or other individuals for 93 per cent of the credit they received.

To meet the needs of low-income farmers for whom even special agricultural credit facilities were not effective, a number of countries developed schemes for combining credit with technical aid. Small farmers who were regarded as bad financial risks by agricultural lending institutions could receive special loans on the condition that they accept technical help in planning and operating their farms. Such programmes of supervised credit, inaugurated in the USA, a number of Latin American countries and elsewhere, were designed to raise farm productivity and thereby enable the farmers to meet their obligations. In addition many countries after the depression of the 1930s provided direct subsidies to one or another aspect of their agriculture.

(*c*) *Agricultural processing and marketing*. Adequate facilities for the processing and marketing of agricultural products were also vital to the efficient operation of agriculture. In countries of advanced agriculture improved transport systems, including the extension of all-weather farm-to-market roads, motor vehicle and air transport, and new methods of processing and preserving foodstuffs, including quick freezing, broadened the farmer's market for perishable as well as for staple foods. In the market economies farm products entered a system of wholesale and retail distribution which became more elaborate with the extension of its scope. In the socialized economies state systems of procurement and distribution handled all except the small amounts which reached local markets.

In the market economies packaging became more elaborate, both to permit shipment and for sale through mounting numbers of self-service outlets where the package rather than a shop assistant acted as salesman. In order to make this form of marketing possible, standards of size, quality and nomenclature were developed, generally by government agencies, and laws were enacted requiring that certain information concerning the content appear

on the labels of containers. Farmers whose product did not meet prevailing standards found themselves at a competitive disadvantage. For the protection of public health, inspection services were established for livestock slaughtering and other processing and buyers came to depend on these safeguards for assurance that the food which they bought was safe.

Increased processing, packaging and shipping made the commercial farmer and the consumer more dependent on the middleman. In order to reduce this dependence and to secure as large a proportion of the consumer's food money as possible, farmers in most of the agriculturally advanced countries formed co-operatives to market and often to process and package their products. Marketing co-operatives, especially strong in Denmark and Holland and very active in other countries of western Europe and North America, became extremely powerful and came virtually to control the marketing of particular products in their areas. In addition farmers formed co-operatives to purchase their seed, fertilizer, tractors and other supplies in order to lower their costs by performing the middleman's wholesale function for themselves. Direct co-operative action by farmers, however, could not protect them against the major economic pressures to which they were subject. Much of their organized effort was therefore directed toward political action to secure the intervention of government on their behalf.

Extensive processing and packaging had not become part of the agricultural economy of the USSR by the 1950s. Handling of farm products in their natural state was still the major problem in getting produce from field to consumer, for distances were great, storage facilities on the farms and at collection points not always sufficient and roads within and to the farms generally unimproved. Inter-*kolkhoz* enterprises, established to serve several collective farms, had as one of their main functions the improvement of roads and storage facilities.

In the underdeveloped countries the inability of the farmer to get his crop to market, waste and spoilage in the process and costly methods of handling were serious obstacles to the improvement of agriculture, the raising of farm income and the reduction of food costs. In addition, farmers often lacked access to essential supplies. In Asia and Africa and parts of Latin America numbers of agricultural villages or hamlets could not be reached by a wheeled vehicle; where roads existed they were often impassable in the rainy season. Storage facilities were inadequate and losses from rodents, vermin, weather or spoilage reduced by as much as a half the volume of produce shipped from the farm which finally reached the consumer. Town merchants often had farmers at their mercy when it came to price. Retail distribution was carried on inefficiently by a great multitude of small traders who made a meagre living selling foodstuffs.

Programmes for the improvement of agriculture in these countries focused on roads, transport, storage and handling facilities, as well as on the industries producing fertilizers, agricultural chemicals and low-cost equipment; some

included measures to improve retail distribution. In India for example, village roads were among the most frequent projects undertaken as community development activities, and fertilizer manufacture was one of the basic industries designated by the first five-year plan as of such importance as to require government operation. The agricultural programmes of most of the Latin American countries included measures to improve storage and marketing, by co-operative effort or as a government service.

4. *Government measures to support farm income*

The crux of the farmer's economic problems in the countries of advanced agriculture and individual farms was twofold: the farmer remained a highly competitive producer of a product whose price he could not control, in an economy where an increasing proportion of non-agricultural prices were administered by corporations or, in the case of wage rates, by agreement between employers and labour unions; and, except in time of war or crop failure, farm production tended to outrun the market as improved techniques raised yields more rapidly than demand was augmented by increased population and rising incomes. The depression of the 1930s demonstrated how extremely vulnerable the agricultural segment had become to the impact of fluctuations in employment and prosperity in the rest of the economy. Prices for agricultural products collapsed, but the farmer's costs remained high, for the companies from which he purchased his equipment and supplies were in a position to hold prices up by cutting down on production. Fixed charges on his debt, moreover, continued regardless of his income.

Farmers who produced for export were particularly hard hit, as in Canada, Australia, Argentina and Brazil, when prices on world markets fell to a quarter of their pre-depression level while stocks of wheat, wool, meat and coffee continued to pile up unsold. Many farmers lost their farms to the banks to which they were mortgaged. United States farmers in some localities resorted to direct action to stop mortgage foreclosures; when a neighbour's farm was put up for sale to satisfy a mortgage debt, they assembled in force, intimidated any outsider who tried to bid, and bought the farm back for a few dollars.

In the face of this situation governments stepped in to protect their farmers from economic disaster. The measures adopted were various, and changed through the years, but in one way or another they provided for a buffer against extreme downward fluctuations in price and in some measure tried to assure farmers a market for their product. Notably in the United States these measures were associated with efforts to limit supply by restricting the acreage planted to particular crops—efforts which were continually undermined by increased yields on the acres which remained in cultivation.

Support measures generally took the form of guaranteeing the farmer a given level of prices, sometimes by government purchases at this price, sometimes by government loans on supplies held in storage against a future price

rise, sometimes by estimating the probable size of a crop and fixing prices so as to sustain a given level of farm income. Some measures were linked to soil conservation, either by making conservation practices a condition for receiving benefit payments or by making it of direct advantage to farmers to engage in such practices. Farm support measures generally applied to specific crops, and were sometimes adjusted to trends in consumption—e.g. away from grains and to 'protective' foods such as milk, fruits, vegetables and meat as incomes rose; at other times they reflected the strength of the producing group and the place of the product in the economy rather than consumption trends or nutritional needs.

A number of countries set up programmes for feeding special groups in the population outside the regular commercial channels of food distribution, through school lunches, infant milk stations and welfare agencies, and they used these programmes for the disposal of surpluses which threatened to depress the market. Whatever the form, these economic measures substituted controlled markets for free markets within countries and involved governments heavily both in regulating and in providing financial backing to agriculture.

Public measures on behalf of agriculture were based on the developing study of agricultural economics pursued by agronomists seeking to understand the farmer's economic as well as his technical problems and economists who applied economic theory to the agricultural segment of the economy. They depended too on the development of statistical techniques for estimating crop yields, insect populations and the effects of weather conditions and for establishing the interrelations among the many factors which play upon production, farm management and the agricultural economy. As a field of study, agricultural economics grew out of a variety of interests followed during the nineteenth and early twentieth century in different European countries—farm management, credit, farm accountancy, agricultural co-operatives—and it reached very extensive proportions after 1920 in the United States and Canada, Australia and New Zealand. In 1929 an International Conference of Agricultural Economists was organized to link the organized societies of specialists in European countries, North America, Australasia and India. Through work in this field economic measures on behalf of agriculture came to be based on elaborate systems for reporting, estimating and forecasting farm production, income, demand, costs and related factors.

At the beginning of the second world war the surpluses accumulated in the USA and Canada provided the initial basis for wartime supplies. Thereafter agricultural production in these countries expanded enormously. Such expansion was encouraged by government guarantees that farm prices would be supported after the war and not be allowed to collapse as they had after the first world war when European agriculture recovered and huge supplies from North America were no longer needed. This expanded production helped to

carry the allied countries through the war and to meet the immediate post-war situation of acute food shortage.

But within a few years, the major producing countries were back to a surplus position, as European farming not only recovered but underwent rapid modernization and European countries took steps to sustain the level of home production for reasons of national security. By the 1950s programmes of agricultural support, which had been inaugurated during the depression and used to stimulate agricultural production during the war, had become a sort of permanent crutch for agriculture. Agricultural technology constantly reduced the number of farmers required to meet the need for domestic consumption and export. But farmers continued to demand the economic protection which governments were committed to maintain and satisfactory measures had yet to be devised which would not depress farm income, would expand consumption, would encourage the withdrawal of surplus farmers to other occupations, and would avoid stimulating the production of crops already in greater supply than the market would absorb.

Food-importing countries such as Great Britain used many devices similar to those used by countries with agricultural surpluses, but with different objectives. Their agricultural programmes were designed in the interests of national security rather than to benefit the farm segment of the population for its own sake or because of the large contribution of agriculture to national income. They supported farm prices and farmers' incomes in order to make it worth the farmers' while to remain in agriculture; they adjusted taxation to stimulate modernization; they sometimes subsidized particular crops, placed quotas on foreign imports and otherwise sought to reduce dependence on outside sources for vital supplies.

By mid-century, agriculture was the most cared-for and protected segment of the economy in the technically advanced capitalist countries. Although many criticisms were levelled at the comprehensive programmes maintained by these countries, including various marketing schemes, subsidies, tax relief, price supports or other measures, these programmes had become so much a part of the world-wide move toward greater security and welfare that they appeared likely to continue to characterize the structure of world agriculture. At the same time the clear relation between city incomes and farm markets made it abundantly evident that the prosperity of agriculture not only contributed to but depended upon an expanding world economy.

In the socialized economies the level of support for agriculture was determined by the contribution expected from the agricultural sector to the total economy. In the early stages of the Soviet economy, agriculture was made to bear the major share of the cost of capital development; since the USSR was a predominantly agricultural country at the time of the October revolution, this was the main source from which national savings could come. The situation was similar in other socialist economies, especially the People's Republic of China. With the establishment of an industrial base, the USSR was in

a position to draw resources for expansion from the industrial sector, while at the same time sustaining the rural segment at a higher level as its productivity rose.[1]

III. FORESTRY

Essentially the same body of basic knowledge was applied to the growing and harvesting of trees as to agricultural crops, but the nature of forests made the process of application different in many ways from that in agriculture.

For a number of reasons the application of scientific knowledge to forestry was largely a matter of public policy: the period of tree growth often extends beyond the life span of man; forest patterns are highly complex as compared with single agricultural crops and involve quite different problems of harvesting and handling; forests affect the maintenance of stable soil and water conditions beyond the immediate locality and the results of sound forest practices are primarily social, benefiting others than those who apply them.

The application of forest technology involved distinct problems in the widely differing forest regions of the world—the large northern forest areas of North America, Russia and Scandinavia, the cultivated forests, mainly in Europe, the tropical forests of South and Central America, southern Asia and Africa, and the regions where forest cover had been largely destroyed, especially in the Mediterranean, parts of China and some sections of the Andes.

The history of forestry in the twentieth century involves the extension of knowledge and of forest policies from the European centre where they had been developed. Knowledge was elaborated and intensified by observation and research into the specific conditions of more and more regions, notably in India, North America, South Africa, Australia and New Zealand, Chile and the USSR. Programmes and policies reflected, and in turn affected, the growing public appreciation of the necessity for forest conservation, the growing body of technical knowledge of forest management, and the technological improvements in methods of harvesting timber and utilizing forest products.

These developments took widely different forms under different conditions: where trees were still a surplus product of nature which man was engaged in reducing, as in parts of North and South America, south-east Asia, Africa and the USSR; in countries short of timber, such as Australia and South Africa; in areas, such as the Mediterranean littoral and much of China, where man had long ago destroyed the tree cover; in regions, notably in Europe, where a stable balance of wooded and open land had been worked out and was being maintained.

1. *Emergence of scientific forestry*

The scientific management of forests grew out of the effort to preserve woodlands as the habitat of wild life which could be hunted for food and sport. Feudal, royal or state forests had long been protected for this purpose, especially in central Europe, and before the nineteenth century some of the

forest wardens entrusted with the care of these forest preserves had begun to observe the growth patterns of trees systematically and to develop systems of cutting which would provide the amount of sun or shade, space and nourishment which favoured the growth of particular species and would permit a forest to maintain itself through the years. In Russia the first experiments in the study, description, mapping and protection of forests had been undertaken in the time of Peter the Great.

In the first quarter of the nineteenth century schools devoted to scientific forest study and the training of foresters had been established in Germany, France and Russia. In these countries, and in the other European countries to which systematic forest management and forest training spread during the nineteenth century, state forests were brought under scientific management, a body of knowledge was built up relating to the growing habits of European tree species, standard cutting methods suitable to different conditions and purposes were worked out, and professional training supplied the personnel which carried the principles and practices of forest management to other parts of the world.

The principal development in the nineteenth century outside Europe had been in India and Burma, where the British government had begun to set aside certain of the teak forests as public reserves in the middle of the century and to develop a trained forest staff for their administration, and in Indonesia where the Dutch administration had brought the teak forests under regulation at the end of the century. A body of British foresters trained for the Indian service in France and Germany, and after 1885 in Britain, had developed techniques for the management of Indian and Burmese forests and supplied the personnel which at the turn of the century was beginning to extend scientific forestry to Malaya, Siam, East Africa and the West Indies. In the Asian areas main attention was focused on the commercially valuable teak, although systematic study of other Indian species was under way.

In North America towards the end of the nineteenth century the virgin forests which European settlers had regarded either as a bar to settlement or as an unlimited source of fuel and building material were beginning to become depleted and Americans were awakening to the need for conservation. The United States government had started to set aside lands as national forests in 1891 and had provided for their scientific management in 1897. The first American foresters had returned from training in Europe to join two or three German foresters in manning the new national forest service, administering the first scientifically managed private forest, and establishing in 1898 the first American school of forestry.

2. *Major developments in forestry practices in the twentieth century*

(*a*) *Sustained forestry*. The outstanding development in forestry in the twentieth century was the spread from Europe to other parts of the world of the principle that forests should be made continuously productive.

Forest management systems were the crux of sustained-yield forestry. European forestry evolved a series of alternative or complementary systems, such as the selective cutting of large trees, cutting of small growth to allow selected trees full use of space and nutrition, or complete cutting of stands where the species required sunlight for seeding in order to permit a new stand to take hold. These forest management systems, whose basic purpose was to perpetuate forest growth, were dependent for their applicability not only on the growth patterns of particular kinds of trees, but on the costs of operation, the uses to which forest products would be put, and on the related public policies to which forest management contributed, such as the protection of watersheds, grazing ranges, wild life or recreation areas.

The conditions upon which this body of knowledge and practice was based were specifically those of Europe: a moist, cool climate, a limited number of commercially valuable tree species, generally porous soils, ample but gentle rainfall offering a minimum threat of erosion, flood or drought, little serious danger from fire and a high demand for forest products together with an ample supply of manpower which made labour-using practices profitable and minimized waste.

Other regions of the world presented many conditions and problems which were wholly outside the European range of research and practice. Climate, soil, water supply, the contour of the land, the varieties and combinations of native trees and the possible uses of forest products all combined to define the problem of forest management differently for each forest area and to set the special terms for effective practice. Ingenious foresters applied the basic principles of scientific forestry to new situations; new bodies of data were developed through the slow process of observing the growth of local trees, the interactions among species and the results of different methods of treatment. As scientific forestry was extended to new areas, a wide variety of forest management practices were developed which were adapted to the combination of factors present in each region.

Sustained-yield forestry took hold slowly in tree-rich North America, but it gained momentum through the years. It spread gradually to other heavily forested regions, in Latin America, south Asia, Africa, Siberia, and to timber-scarce areas such as Britain. By the middle of the century a growing body of experience and knowledge, combined with a widespread movement for conservation, had brought acceptance of the principle, if not the practice, of continuously productive forestry throughout the world.

(*b*) *Forest plantations.* Sustained-yield forestry depends on the pre-existence of a forest area. The open steppes, the treeless prairie or veld and regions denuded of trees by over-felling require a different approach.

Forest nurseries where trees were grown for use in afforestation had been well established on the European continent and in Britain during the nineteenth century and were widely extended in many regions. In these nurseries experiments with seed beds made it possible to determine conditions

of sun and moisture most favourable to initial survival and growth and to check these against knowledge gained by observations in the natural habitats. These studies made it possible to go beyond the practice of reproducing natural conditions and to select and breed strains which showed particularly rapid rates of growth or other special characteristics.

Forest plantations where these rapidly growing species of trees were scientifically planted and harvested were successfully established and their cultivation and management were developed to a high level, especially in South Africa, Australia, New Zealand and Chile. In South Africa nearly 2,000,000 acres of land were set out in forest plantations, some three-quarters under commercial operation and the remainder by the state. At mid-century plantation methods were spreading to many areas, as it began to appear that timber, pulpwood and pit-props might be produced more cheaply in man-made plantations on favourable sites than through natural regeneration in managed natural forests. Forest plantations were encouraged by state subsidy and by public operation in Britain, they were increasing in Scandinavian and other European countries and were becoming widespread in the United States.

(*c*) *Tree genetics.* Research in many places and under many conditions constantly added to the number of trees whose growth habits were known. In the course of these fifty years most of the major North American species were identified and their main characteristics studied, as were some five hundred or more potentially useful tropical trees in south Asia. Wherever forest services were established, local species were subjected to study; in addition expeditions from North American and European institutions made studies in areas such as parts of Latin America where such services were lacking.

Data remained inadequate in many regions, however. For the North American forests, where a single area often contained as many as thirty major species of trees, it was a mammoth task to determine not only the habits of each species but the ecology of the whole group and the possible response to many possible changes. Only time and long experiment could yield full data on the many growth complexes and their response to changes in the environment. For many tropical and semi-tropical forests, ranging from dense rain-forests and jungles to arid areas where trees could barely survive, scientific study was still in its infancy at mid-century. Attention was being extended, however, from a few commercially valuable species such as teak, mahogany and rubber to the growth and possible uses of unexploited types.

Beginnings were being made in the application of genetics to silviculture, especially in Sweden, Denmark and the United States. Experiments in selection and hybridization, which had been started in the 1930s, were bearing fruit, and work in tree breeding was expanding rapidly in many regions. Except in the growing of nursery stock little work had been done in the field of tree nutrition and fertilization under forest conditions.

(*d*) *Protection of forests against fire, disease and pests.* Protection of forests

against fire, disease and pests was vital to forest conservation and management, especially under the conditions which prevailed in North America. The vast forest areas of Canada and the United States, often difficult of access and frequently dry, required methods of fire protection which had not been so necessary a part of European forest practice. By mid-century, however, fire protection was being actively promoted in European countries also.

Forest fire control was based on the principle that fires must be detected immediately and fought when they are small and manageable, they must be subjected to an all-out attack, and no area, public or private, can be exempt from protection. On this basis the United States and Canada developed elaborate systems of look-out stations, communications, and organizations to summon fire-fighters quickly and deliver them swiftly to their station, and a similar system was set up in the USSR. The introduction of the bulldozer in the 1930s provided fire-fighters with an important tool for opening up lanes in the path of the fire to prevent its spread; the fire services evolved techniques for dropping fire-fighters by parachute on the far side of a burning area; air patrols in time supplemented stationary lookouts, and helicopters made it possible to pick up the parachutists and transfer them to other areas.

Scientific studies of the conditions which produced fires led to the development of ratings of fire danger and permitted more effective use of the organization for constant vigil and swift attack. With the aid of such ratings, fire-susceptible areas were spotted in advance, personnel was alerted and concentrated in danger zones, and areas were closed to the public when fire danger became most acute. Fire itself became a protective tool, as studies of its use indicated when prescribed burning could safely and effectively be used to reduce the fire hazard from accumulated underbrush and at the same time could eliminate disease carriers and breeding grounds for pests and provide an improved seedbed for trees of certain types.

By mid-century approximately 70 per cent of the forest land of the United States—all the federal and state forest land and a large proportion of the privately owned—was under systematic fire protection, and on these lands the burned area was held down to about six-tenths of one per cent of the area protected. On the private lands which were outside the zones of protection the proportion of the area burned by destructive fire was estimated at twenty-five times that of the protected lands.

Techniques for the control of pests and disease were less well developed than those for the control of fire. Although the amount of destruction, especially from pests, was known to be high, control measures were rarely launched until a disease or infestation reached epidemic proportions. A few major compaigns were successful in bringing a particularly destructive blight or pest under control; for example, adequate measures were taken on the west coast of the United States (1910–34) to check the chestnut tree blight when it appeared there, after it had completely destroyed the chestnut trees on the east coast.

Towards the middle of the century some of the new weed and pest control chemicals from agriculture were being used experimentally in forests, including aerial spraying of DDT to combat leaf-eating pests. In addition, studies of the habits of pests and the kinds of growth likely to act as carriers of disease led to the development of forest practices designed to lessen the likelihood of their spread. The economical application of such practices, however, depended on carrying out the fire-control principle of early detection and all-out attack. At mid-century Canada was incorporating this principle into its forest protection programme by training its forest rangers to watch for and recognize signs of blight or infestation as well as fire, and to organize equivalent attacks on disease or pests, and the United States was beginning to follow suit.

(*e*) *Mechanization of forest operations.* The mechanization of logging operations, with the use of portable, motor-driven saws, bulldozers to clear logging roads, and motor transport to supplement streams, slides, logging railways and animal power, revolutionized lumbering. When hand methods were used, it was often profitable to bring out only the main trunks of the trees, leaving as much as 40–60 per cent of the wood behind, and the losses under traditional methods of transport were also high. Mechanized operations cut waste in logging and transport and reduced the labour required to a small fraction of that used before. Technical guidance in the introduction of logging machinery and in the maintenance and repair of logging equipment was one of the areas in which the FAO and the United States technical assistance programmes were called upon to provide aid, especially in Latin American and Asian countries.

Mechanization was applied much less widely and successfully to the planting and cultivation of trees than to their harvesting and processing. As compared with agriculture, silviculture continued to be a labour-using activity, especially under conditions of steep or rocky terrain.

(*f*) *Utilization of forest products.* Technical development in the uses of wood were also revolutionary. At the opening of the century, wood was used chiefly for fuel, for structural material in the form of solid boards or beams, for containers, for the manufacture of articles such as furniture and for the manufacture of paper from certain specific types. For most of these purposes, only good logs for sawn boards or pulp were used; the rest of the cut timber was discarded in the woods or burned as fuel in the mills.

By the middle of the century new chemical processes for reducing wood to pulp and for bleaching greatly extended the range of types suitable for paper making, and more elaborate processes for utilizing the cellulose content of wood from chips as well as from solid logs made it possible to use all sorts of bits which could be ground up and converted into pulp. For the production of synthetic rayon and many of the plastics, the cellulose content of wood was extracted and converted to a liquid which could be drawn into fibre or extruded in plastic sheets. The development of new, stronger and

weather-resistant adhesives led to the substitution of plywood for solid wood in containers and wall panels, greatly reducing the amount of wood used and the space occupied by it for a given strength and purpose. As applied to containers for war material during the second world war these developments were credited with reducing the shipping space required by one-fifth, as well as providing better protection from damage in transit and a 10 per cent saving in lumber used.

Methods of preserving wood against decay and insect attack by impregnation with chemicals and oils made woods usable which had formerly been uneconomic because of their rapid deterioration and they prolonged the life of poles, piles, railway sleepers and posts. In a period of thirty years the amount of wood needed for the replacement of railway sleepers in the United States was reduced by 60 per cent as a result of new techniques of wood preservation and treatment. Still other uses resulted from the distillation of wood sugars, first for alcohol during the first world war and then to produce molasses for animal feed and, under conditions of sugar shortage in wartime Germany, for human food.

These technical developments in the utilization of forest products not only expanded the variety of trees which were commercially valuable but indicated the special properties of wood that were desirable. In some cases, these properties could be enhanced by one forest practice rather than another. At mid-century the relation between specific properties of wood and conditions of growth of some species was beginning to be sufficiently understood to serve as a partial guide to forest practices designed to yield the maximum proportion of the kind of wood desired.

(*g*) *Uses of forests to conserve water, soil and wild life.* Forests are not only a resource which can be scientifically managed in order to produce a sustained yield of a valuable crop; they are a means of conserving soil and water and providing a habitat for wild life. Interest in their conservation began to spread to various parts of the world in the last quarter of the nineteenth century, as people became aroused lest the ecological balance of nature be so upset as to bring unforeseen and dangerous consequences, lest species of life become extinct, and lest man in the future should no longer have the opportunity to know and enjoy nature in an unspoiled state.

In forest-rich North America public attention was directed first to the preservation of the remaining stands of virgin timber and of the wild life which inhabited the forests, and then to the relation of forests to flood and erosion control. One of the first American foresters, Gifford Pinchot (1865–1946), who did more than anyone else to arouse public consciousness and interest in forest conservation in the United States during the first quarter of the twentieth century, used pictures of treeless, eroded and flood-wrecked areas of China to dramatize the need to protect the forests before it should become too late. An International Conference for the Protection of Nature was held in 1913 in Switzerland and an international office was established in

Brussels in 1928. By the second quarter of the twentieth century conservation had become a world-wide issue as books bearing such titles as *Deserts on the March* (by Paul B. Sears, Oklahoma, 1935) warned of the dire consequences of continued neglect of the imperatives of conservation.

The issue was dramatized by a series of floods and dust storms in the 1930s in the drought-stricken dust bowl area of the central United States, where grass cover had been ploughed under and dry farming undertaken in response to the high farm prices of the first world war. Possible remedies were also dramatized in that country when the Tennessee Valley Authority was set up in 1933 to develop the whole of a great river valley by the application of forest and grassland practices, construction of dams, control of floods and the provision of electric power and navigation. The TVA fired the imagination of people in other countries who projected similar valley development programmes in which watershed protection through forest conservation and reforestation would form a vital part, such as the Snowy River project in Australia, the Damodar Valley project in India and extensive river development projects in the USSR and China.

Toward the middle of the century studies of the role of forests in conservation were extended to include the part played by forests as consumers as well as conservers of water. The flow of streams from areas where the forest was unbroken was compared with that from similar areas which had been partially cut, and as much as a third to a half as much additional water was found in some cases to enter streams from the opened slopes. Such planned cutting reduced water consumption by the trees themselves by lessening their number, and it permitted snow to reach the ground instead of evaporating from the tree tops. The concept of watershed management as opposed to mere protection was thus developed and ways were sought to balance the objective of flood and erosion control with that of maximum water supply in areas where rainfall was seasonal or scarce. In snow areas the development of windbreaks to induce drifting was undertaken in the effort to create snow reservoirs which would melt slowly and continue to deliver water after the undrifted snow had gone.

Wherever open grazing was practised the problem of range management was linked with the management of existing forests or with new planting. Goats which overgrazed whatever area they penetrated prevented the natural rejuvenation of forests by eating down new growth as it appeared. Especially in the Near East and along the slopes of the Andes, goat control was the *sine qua non* of forest management, reforestation, and watershed protection. Overstocking of ranges and uncontrolled grazing of cattle presented a similar problem of serious proportions in parts of the United States, India and Russia.

The most difficult problems of conservation arose where forest or grass cover had already been destroyed and remedial reforestation or afforestation was required. In the 1930s both the United States and the USSR launched

large-scale programmes for the planting of shelter belts in their open plains in order to check wind erosion and perhaps to affect the climate of the areas. Both programmes were fairly successful in establishing stands of trees. Evidence as to the possible effect of these belts on climate, however, appeared to indicate that their effects were confined to the very immediate locality. The Russian programme to extend the planting of shelter belts for many hundreds of miles was continuing at mid-century.

Along the Mediterranean littoral, the Tigris–Euphrates valley, parts of India and much of China, where population had been dense for thousands of years, conditions were extremely unfavourable to reforestation. The tall cedars of Lebanon and their counterparts elsewhere had long since been cut, and much of the unprotected soil had washed, blown or leached away, leaving stony hillsides or spreading, windswept deserts and annual dangers from destructive floods. In these areas the beginnings of economic planning in newly established countries, supported by the momentum of the conservation movement and the stimulus and technical assistance of the United Nations Food and Agriculture Organization, set efforts in motion at mid-century to reverse the age-long process of physical deterioration.

Arid lands presented the most baffling, but some of the most important problems in reforestation. At mid-century no solution to the problem of dry land planting had yet been found, but research and practical efforts were being carried on in a number of areas, notably in the arid regions of India, the United States, the USSR, Australia, Israel and China.

3. *Forest policies and programmes*

Progress in the application of scientific forestry depended to a major degree on the adoption of national forest policies. Since the benefits of forest practices become apparent only after many years and do not accrue solely to the owner of the forest land, public measures were required to secure sound forest management. Most forest legislation applied principally to domains under public control, scientific practices were most widely introduced on public lands, and research and experiment were chiefly supported by public funds.

Forest policies and programmes took the form of the administration of state forest lands; regulation of designated areas to protect water sources, check erosion or preserve wild life; measures to protect private as well as public forests against hazards of fire or pests or to regulate or supervise their cutting; financial and technical aid to private individuals; and programmes to educate forest users and promote sound practices.

(*a*) *European programmes*. By the opening of the twentieth century most continental European countries had effective forest codes and administrative structures for controlling forest practices on state lands. A half to two-thirds of the forest lands in most European countries, however, were in private

hands and a substantial proportion of the public domain belonged to municipalities, cantons or communes, sometimes only partially subject to national control.

European forest programmes in the twentieth century were largely designed to improve the practices in public forests and to extend productive forestry to as large a proportion as possible of the total forest area of the country in order to maintain forest resources at least at existing levels and to preserve their protective features. Most European countries strengthened their forest laws and intensified both administrative and promotional activities. They differed in the extent to which they brought private lands under control, from Switzerland, where all private and cantonal as well as national forests were placed under the surveillance of federal forest police in 1902 and nearly three-quarters of the forest lands were subject to strict cutting regulation by 1904, to France, where private lands constituting nearly two-thirds of all forests remained free from the restrictions of the forest code and the supervision of state foresters.

The two world wars had a profound effect on European forest programmes and policies, for they not only destroyed the forests which lay in the path of combat but stimulated excessive cutting to meet the heavy wartime demands for wood. In areas such as Germany where the combination of regulation of state forests and voluntary measures on many large private areas had established a balance between growth and extraction, cutting exceeded replacement during much of the period after the beginning of the first world war. By 1954 the forests of the German Federal Republic had been restored to a balanced yield. In the states of eastern Europe, which inherited their forest laws from the 1852 forest code of the Austro-Hungarian Empire, the need of a cash export crop in the inter-war years added to wartime destruction and demand to deplete the forest resources of these areas. Although these countries launched planned reforestation programmes after the second world war to regain self-sufficiency and a sustained output, the process of depletion appeared to be still continuing at mid-century.

The northern European countries adopted strong programmes for both regulation and promotion. They forbade the cutting of young forests except for thinning, and limited cutting of older growth to that which would maintain a sustained yield; they developed local commissions or boards to oversee such regulations and they formed co-operative organizations which employed foresters to provide technical guidance to local owners. The Netherlands required a licence for all cutting, but succeeded in bringing less than a quarter of its woodland under sustained-yield management. Britain, which was aroused to acute consciousness of its dangerous lack of wood when the first world war cut off imports, adopted its first effective forestry act in 1919, setting up a state forestry commission which took over the royal forests and planted a million acres by 1957. After the second world war the commission was given control over felling in private woods and inaugurated a system of

'dedication' under which the owners of private woods accepted supervision in return for financial grants.

(*b*) *North American programmes.* In the large forest areas of North America, which furnished a quarter of the world's commercial wood supply in the twentieth century, direct measures to restrain cutting were almost wholly confined to forest lands in the public domain. For the United States from 1891 on, successive legislative acts extended the authority of the federal government to retain or to acquire forest lands in order to conserve a national resource, for stream and watershed protection and finally without specific limitation; they also provided authorization and funds for forest protection and forest research. By 1955 national forests, together with forest lands similarly set aside by the states, amounted to a third of the forest land of the country, but they accounted for only 10 per cent of the timber which was cut annually.

The federal government exercised no direct control over cutting on private land but it extended fire protection (1911) and later, pest control (1947) to these areas, and after 1924 it co-operated with the states in providing free or cheap planting stock for conservation and shelter belts and it offered bonuses for various conservation practices. During the depression of the 1930s, unemployed youth, organized in a Civilian Conservation Corps, were set to work on conservation projects throughout the country. From 1937 on, a forest extension service similar to the agricultural extension service offered technical advice to farmers on the management of their woodlands and to owners of timber stands on mangement procedures appropriate to each area. A majority of the states revised their tax laws in order to encourage rather than to discourage good forest managment. Forest planting on private farm lands was stimulated by the distribution of low-cost trees from state forest nurseries to farmers at rapidly increasing rates which reached several million trees a year by the mid-1950s.

Much destructive cutting by small farmers and lumber companies continued. But the combination of conservation subsidies, technical advisory services, the supplying of trees to farmers at nominal cost and the recognition by commercial companies of the practical value of scientific forestry measures was bringing sound forest management to an increasing proportion of the forest lands of the United States.

In Canada all except 6 per cent of the vast forest area was publicly owned, three-quarters by the separate provinces, each of which had its own programme of administration and control. The provincial and national Crown lands were exploited chiefly under licences issued to private companies, and the principal method of control was to require the licensees to submit working plans before receiving the right to cut. Increasingly, licensees were required to maintain a sustained yield, but a number of the provinces in the 1940s and 1950s considered their forest policies inadequate and appointed commissions to review their programmes, while the national government in 1949 instituted a programme of aid to the provinces for forest management.

The eastern provinces, where most of the private forest land was located, established forest services to aid in the development of farm woodlands and one, Nova Scotia, took the first step to control private forests directly by enacting legislation after the second world war requiring permission to cut all trees under ten inches in diameter.

(*c*) *Forest programme of the* USSR. The forest programme of the USSR was one of the most ambitious. It was based on the forestry traditions of Europe, for German methods had been adopted for the administration of the tsar's forests, and the Leningrad Institute was one of the oldest forest research institutes in the world. Combined with these European traditions of forest management were vast forest resources and frontier conditions similar to those of North America. Forest policy in the USSR was directed toward the full development of timber resources and the wide use of forests for protection and conservation; forest projects were given high priority in respect to capital investment, machinery and equipment. Guided by research carried on in a dozen major and a multitude of lesser forest research institutes and experimental stations, and supplied with a large body of trained personnel by forestry schools which graduated several thousand foresters and forest technicians annually, Russian forest operations moved eastward to tap the relatively undeveloped resources of Siberia and to supply wood for the eastward moving industry and population of the USSR. The first large-scale pulp and paper mill in the Far East was established at Komsomolsk on the Amur river in 1942.

Large areas of forests were set aside as screens around health resorts and industrial centres, and forests on watersheds and river banks were designated as protection forests where cutting was restricted. In a gigantic fifteen-year undertaking to 'remake nature', the USSR launched in 1948 a project to erect a 5,000-mile forest barrier against hot south-east winds, to plant shelter belts around cultivated fields on some 12,000,000 acres of open land, to create some 44,000 ponds and reservoirs, and to build hydroelectric power and irrigation systems and a series of major canals. These measures were designed with the hope that they would convert a wide, treeless, windswept area of steppe and desert into a balanced green landscape, to modify the climate, to increase crop yields in the protected areas and to bring former desert areas into cultivation.

(*d*) *Programmes for tropical zones.* In most other parts of the world programmes of forest management and conservation were limited, but by mid-century nearly all countries maintained some form of forest regulation and service for their public domains and the development of forest resources was part of their plans for economic development. In most tropical and semi-tropical areas—south and south-east Asia, Central and South America and Africa—the situation was similar. Near centres of population forests were so depleted that even firewood was scarce; in less accessible regions forests were almost untouched and often unexplored.

The most elaborate programmes for tropical areas were those originally established by the British in India and Burma to manage the reserved forests under public authority and to regulate some additional protected areas. At the opening of the century 20 per cent of the reserved lands of India and Burma were being administered according to scientific principles; by 1933 three-quarters of such lands were under approved working plans. The Indian government after 1947 laid out a programme for reforestation to check the progressive deterioration of the soil in some areas, for the establishment of village woodlands, and for the continued management of public forests with a view to making use of a wider range of tropical trees. These programmes encountered severe technical and administrative problems arising from the character of the land to be reforested, for it was difficult to find suitable species and to devise planting patterns to withstand the severe climatic conditions while trees were becoming established. In addition the extreme shortage of fuel in densely populated areas made it difficult to protect plantings against depredation.

In other countries of south and south-east Asia, forest programmes were being directed toward the fuller use of forest resources and the protection of forests in inhabited areas against waste from the widespread practice of shifting agricultural cultivation.

Among the countries of Central and South America few effective forest policies were adopted until after the second world war. Mexico had begun to develop a reforestation programme in the early years of the century; Brazil and Chile enacted laws in the 1930s to regulate cutting but did little to enforce them. After the second world war most of these countries took steps to adopt or revise forest legislation, to establish or strengthen their forest services, to launch programmes of reforestation and to develop methods for exploiting their lowland jungles. The largest number of technical assistance projects by the forestry division of the FAO during these years were in Latin America.

In tropical Africa most of the forests remained unexploited except for limited and specific purposes, chiefly in east Africa. Some areas were reserved as preserves for big game. Only a beginning had been made by mid-century in developing techniques for sustained forestry, and in creating forest reserves which would prevent destruction prior to the development of sound practices.

(*e*) *Programmes for denuded areas.* Where forest cover had been most completely destroyed, as in China, the eastern Mediterranean and parts of the Andes, only drastic measures for reforestation under most difficult conditions could begin to undo the results of centuries of abuse.

In China interest in forest conservation and reforestation began after 1911, but it was not until 1938 that a national forest law was enacted, modelled on that of Japan, and a forest administration established, and only after 1949 that vigorous measures for forest reclamation were launched. The 1938 law gave the central government the power to establish areas as 'protection forests' which no one might cut or damage, to compensate the owners of such

forests and to require persons who benefited from forestry work done by an owner to bear part of the cost. After 1949 an elaborate administrative organization was developed to administer the 'protection forests' and provincial forest lands, grant licences and supervise cutting on other land, and to organize and stimulate the reforestation of denuded areas. An immense tree-planting campaign was launched which stimulated farmers' organizations and especially youth groups to undertake projects for planting millions of trees. At mid-century the task of restoring tree-cover to China's vast bare regions overshadowed all other aspects of its forest programme.

In other treeless regions, South Africa developed extensive plantations, using entirely imported trees. Australia concentrated its efforts on the introduction of softwoods which could provide raw material for paper, on planting experiments in some of its dry regions and on measures to control the acute fire hazard. In the denuded areas of the eastern Mediterranean and the Middle East, forest programmes were in their infancy. Turkey had a well-organized forest service but had not yet checked abusive cutting on its remaining wooded areas. In most other countries of the area a bare beginning had been made by mid-century on the multiple and difficult problems of reforestation. Only in Israel, where tree planting became a symbol of the national effort to reclaim the land, had substantial headway been made toward reforestation in this region.

(*f*) *International co-operation in forestry and forest policies and programmes.* The inclusion of a forestry division in the United Nations Food and Agriculture Organization signalized the world-wide importance of forest development and its relation with food and agriculture. The aspects on which the FAO was called on to provide technical assistance during its first ten years indicated the needs of the different regions. The largest number of its projects were in the forest-rich areas of Latin America, where the aid sought was initially in the development of forest policy, drafting of forest laws and establishment of forest administrations; thereafter specific projects constituting parts of the countries' programmes for rational exploitation of their forest resources, such as settlement of the Amazon basin of Brazil or development of forest industries in Paraguay, received FAO assistance and led to the setting up of a regional research and training institute in Venezuela.

In the Near East, by contrast, the almost total absence of remaining forests led to requests for assistance in reforestation, grazing control, soil conservation practices and the training of foresters, and to plans for a regional training centre for the area in Iran. Most of the countries of south and south-east Asia inherited forest policies and services from the British and Dutch colonial administrations which had been concerned with the extraction of the valuable lumber crop, mainly teak, and requests from these countries were largely in relation to new uses for additional types of woods, and new techniques of logging, transport, drying and preservation. Some assistance was also requested from this area to improve forest practices and

check indiscriminate burning where this method of clearing for shifting cultivation persisted.

4. *Forestry, forest policies and conservation at mid-century*

At mid-century the science of forestry was still in its infancy, in spite of its long history and rich development in Europe, because of the enormous regional differences between areas which required the repetition elsewhere of the kind of long-term observation, experience and experiment which had given European forestry its sound local base. The technology of wood utilization was in a stage of very rapid development which greatly increased the range of forest products which could be economically exploited.

The conservation movement had become world-wide; the International Union for the Preservation of Nature, organized in 1948 with the co-operation of Unesco, was composed of more than 150 national and international conservation organizations and official bodies in some thirty countries. In many areas, however, the movement was still not sufficiently strongly supported by individuals in their private behaviour and governments in their public programmes to reverse the trend toward the depletion of resources.

Forest conservation was part of a many-faceted struggle to retain the world's soil, water and renewable growth and to preserve them against the depredations of mankind. Sound forest practices generally required social as well as individual action, but they depended also upon the co-operation of individuals and their willingness to pursue long-range rather than only short-term goals and to consider the effects of their actions on others as well as themselves. It was the claim of scientific forestry that the social conscience and responsibility of a people could be measured by the way in which it handled its forests.*

IV. FISHERY

Fishing, too, received new impulse and took new shapes in response to the scientific and technological developments of the twentieth century. During the first half of the century the volume of fish production doubled. For the world as a whole, however, this meant little or no increase in the *per capita* amount of fish caught, for the expansion of fish production was roughly in proportion to the increase in world population during these years. But for those countries where fishing reflected an advanced technology and expanding economy, notably northern Europe, North America and Japan, it meant a large growth in volume and marked increase in the productivity of persons engaged in fishing. Toward the middle of the century fishing developed rapidly in several new areas, and its techniques began to be revolutionized in regions where traditional methods were being replaced by modern technology.

* See Franz Heske, 'Forestry in the Twentieth Century', *Journal of World History*, vol. v (1959), p. 748.

1. *Deep sea fishery*

(*a*) *Fishing methods.* The major expansion in fish production was made possible by the mechanization of fishing operations and technical developments in the processing and preservation of fish and fish products. The early steam trawlers, sent out by France in the 1870s and by Britain and Germany in the 1880s, presaged the substitution of motor power for sail and oar which became virtually complete in northern Europe, North America and the USSR by the second quarter of the twentieth century and was very extensive by mid-century in Japan. Powered trawlers, operated at first by steam and later also by diesel engines, could travel to distant fishing grounds. Equipped with otter boards which held open the mouth of the seine as it was dragged over the floor of the ocean, and with power hoists to raise the catch, these boats could haul in large quantities of fish in a short time. As their power and speed were increased—up to ten or even twelve knots by the middle of the century—and their design was improved, they could go farther, be more independent of weather conditions and bring back their catches in a shorter time.

Smaller fishing craft, too, were almost completely motorized in these countries by the middle of the century. Fishermen whose boats were powered by petrol engines could tend many more traps than those dependent on sail or oar, and they were less limited by weather and distance. Improved gear was also developed for small craft, such as the light Danish seine which was widely adopted in a number of countries.

In the years following the second world war, and especially after 1950, mechanization spread rapidly to new areas from the major producing countries to which it had hitherto been largely confined. In 1950, for example, only some 50 of the fishing boats in the Indian state of Bombay had engines; by 1955 there were more than 600. The fishing fleets of Hong Kong, Singapore, Ceylon and Indonesia were undergoing a similar motorization and even some of the Pacific islanders were substituting motor boats for outrigger canoes. Some of the smaller producing countries, such as the Philippines, the Union of South Africa and French Morocco, increased their output three to five times from before the war to the early 1950s, South American production doubled, and that of Angola increased nearly ninefold. The governments of economically developing countries frequently facilitated the process of technological change.

The use of electronic devices was second only in importance to the application of motor power and the design of fishing boats and gear. Electronic echo-sounders, or sonar, developed as aids to navigation and for the detection of submarines, were found to be of great value to fishermen in detecting schools of fish. At first used principally on ships engaged in fishery research and then by special scouting vessels such as those sent out by the Norwegian government in the 1940s to spot schools of cod and advise fishermen of their

whereabouts, the echo-sounder came to be part of the equipment of many fishing vessels. Radio communication gave fishermen access to news of weather conditions and the whereabouts of fish; in some cases spotting planes circled near-shore fishing grounds to report the presence or absence of fish in the area.

Yet with all these technological improvements, fishing remained a hazardous occupation and an uncertain venture, and it continued to be carried on primarily by those who had followed the sea for generations.

(*b*) *Processing and preserving of fish and fish products.* Improved techniques for processing and preserving fish paralleled changes in catching methods. By mid-century a quarter of the fish taken from the seas and inland waters was canned, frozen or reduced to fish oil and meal, while half continued to be consumed fresh and a quarter was preserved by the traditional methods of salting, smoking and pickling.

Though fish canning had been developed in the nineteenth century, it was not until bacteriological studies in the twentieth century provided a basis for standard canning procedures that canned fish became a safe product. Canning industries, processing chiefly sardines, salmon and tuna, developed extensively and reached a high level of technical efficiency and automation not only in the major canning centres of the United States and Japan but in many other areas from South Africa to Siberia.

The development of quick freezing offered more revolutionary possibilities. Refrigeration with ice, both in the holds of vessels and for distributing fish to inland places within the temperate zone, was well developed at the opening of the century, but this method of preservation could keep fish in good condition for only short periods. Quick-freezing and low-temperature storage could preserve fish virtually fresh for months. These processes were developed in the 1920s after it was discovered that the rapid formation of crystals did not break down the cell structure as did the slower formation resulting from slow freezing, and that enzyme action in fish was halted only at very low temperatures, $-29°$ to $-31°$ C ($-20°$ to $-24°$ F). The United States was much the largest producer of frozen fish, but the method was used increasingly elsewhere, especially in Canada, Iceland, some parts of Europe and the USSR.

A growing proportion of the total fish catch was reduced to oil and fish meal; at mid-century the amount so used exceeded that which was preserved by canning and freezing. The fish meal and oil industry absorbed more than half of the African catch and nearly a quarter of the European and North American, and was the basis for rapid expansion in herring and pilchard fisheries in several areas. Its economic importance was considerable. By salvaging some of the wastes formerly discarded in cleaning and filleting the fish and by using the miscellaneous fish hauled in the nets, fishermen were able to realize a higher return from their total catch. As the value of the vitamins and minerals supplied by fish in all its forms came to be appreciated,

methods of refining fish oils and of making fish meal palatable were developed, and products which had been thrown back into the sea or used as fertilizer were converted into animal feed and at mid-century were beginning to be used as human food.

These methods of processing, which involved using the fish in its fresh state rather than dried or salted, made it necessary to bring the fish to the processing point before its quality had had time to deteriorate. In spite of the greater speed of fishing vessels and improved methods of refrigeration in insulated holds, shore was too far away from some of the fishing grounds. Even the fish sold fresh in European markets was often too old to be offered as a first-class product by the time it reached the consumer; a survey in 1950 found this to be the case for half of the fish on sale.

Floating factories which accompanied fishing fleets and freezing equipment installed on fishing vessels were partial answers to this problem. The first of the whaling factory ships entered the Antarctic in 1904, and thereafter provided the means for processing most of the whales caught in that area. Floating salmon canneries accompanied Japanese fishing fleets in the north Pacific. The first of the United States factory ships for converting herring into meal and oil was put in operation in the 1920s, followed by others in that country and Norway. Towards the middle of the century freezing equipment began to be installed on some individual fishing vessels, and newly designed freezer-trawlers were being sent out by Britain, the United States, France, Germany and the Soviet Union.

The new fishing technology brought changes in the organization of the fishing industry, for large motorized vessels and complex gear involved heavy capital investment beyond the reach of most individual fishermen. In Great Britain, Germany, Japan, Canada, Portugal and the United States, a growing proportion of fishing operations was conducted by fishing companies which often combined catching, processing and marketing. Frequently they sent out fleets with 'mother ships'. Some mother ships, like most of the Portuguese, simply butchered and stored the fish caught by the smaller vessels. Others, such as the American tuna clippers which operated in the southern Pacific and elsewhere, were elaborately equipped with tanks for live bait, canning or freezing equipment, and sometimes even planes for spotting shoals of fish. In countries such as Norway and Iceland where much of the catch continued to be salted or dried, the individual skipper-owned vessel persisted to a greater extent. Fishermen's co-operatives were formed in a number of countries for marketing the catch and purchasing equipment and supplies.

(c) Scientific knowledge of fish characteristics, habits and environment. Throughout these years deep-sea fishing remained, as it had always been, a hunting activity. But during the period substantial headway was made in scientific efforts to discover the habits of different types of fish, to understand ocean and climatic conditions affecting their growth and migration, to deter-

mine the ecological balances among species and in relation to sources of nourishment and other aspects of the environment, and to evaluate the effects of fishing under various conditions on the supply of fish in future years. By mid-century these developments brought ocean fishing closer than it had ever been before to being an activity which sought to manage rather than merely to exploit the resources of the sea.

Scientific investigation into the characteristics and habits of certain species of fish was well under way by the opening of the twentieth century and continued to be carried on by constantly improved methods. Some of the more commercially valuable types, such as the Arctic herring and cod which made up nearly half of the total European catch, were studied by various means, including tracking with the aid of sonar sounders, until much was known about their breeding places and habits, their feeding grounds, their movements throughout the year, their relation to ocean currents and their place in the ecological balance of ocean life. Much research of this type was conducted aboard fishing vessels, or by special research ships equipped as fishing craft, and was based on the experience and observation of fishermen as well as of scientists. The USSR used a specially equipped submarine for this purpose.

Oceanographic research, aided by improved instruments for measuring and recording ocean temperatures and sampling water at various depths as well as for sounding and for exploring the ocean floor, threw light on the environments within which fish were found. Uniform procedures made it possible to derive more complete information from scattered observations, as was evidenced in the picture of environmental conditions in the North Sea secured in the late 1940s by simultaneous crossings of that sea according to a uniform plan by seven fishery research vessels from seven different nations.

Statistical analyses of numbers, ages and types of fish caught produced a growing body of knowledge which threw light on characteristics of the stock, and on factors, such as conditions affecting the young, which influenced the volume of fish in an area. This and other research provided an increasingly scientific basis for forecasting annual yields, for guiding fishermen to profitable fishing grounds and for protecting sources of supply. By mid-century a theory of fishing had been worked out covering such aspects as survival of young, growth, migration, natural mortality and mortality from fishing, and complex calculations were being made as to what fishing practices would maintain fishing grounds at productive levels.

(*d*) *Conservation of the resources of the sea.* In the course of these years it became apparent from a number of examples that fish in the sea were not an inexhaustible resource which could be pursued without thought of the effect of fishing on future supply. The danger of overfishing was dramatically apparent in the exhaustion of the halibut fishery off Greenland in the 1930s and the threat of extermination of the Antarctic whale. In the much-fished North Sea catches were exceptionally large and of improved quality after

fishing had been interrupted by each of the two world wars. These experiences pointed to the need for measures to manage these fishing grounds in order to achieve the goal set forth by the United Nations International Technical Conference on the Conservation of the Living Resources of the Sea in 1955: 'to obtain the optimum sustainable yield so as to secure a maximum supply of food and other marine products'.

Many national governments, which had long been concerned with their fishing industries as training and recruiting grounds for sailors, inaugurated or extended programmes of research, information and, often, economic facilitation in line with their overall economic and development policies, and took steps to conserve the resources of their territorial waters. They joined internationally to increase the knowledge of the sea and to regulate some aspects of fishing on the high seas.

Formal international co-operation in marine research and conservation was inaugurated in 1899 with the establishment of the International Council for the Exploration of the Sea by the fishery nations of north-western Europe. International commissions were set up in 1923 and 1937 to regulate the amount of halibut and salmon respectively which could be caught each season in the north Pacific area and the time of year when fishing could be carried on. An international convention for regulating the meshes of nets and size limits of fish in the North Sea was adopted in a preliminary form in 1937 and made formal in 1954. Attempts to restrict Antarctic whaling began in 1931, and were intensified after the International Whaling Commission, formed in 1946, undertook to fix hunting seasons and catches and to supervise the catching and processing of whales.

After the second world war international commissions with regulatory functions or with the duty of formulating regulatory proposals for the approval of member governments were formed for the north and north-west Atlantic and for the north and south-east Pacific. The United Nations organized technical conferences on the conservation of marine resources in 1949 and 1955 and set its International Law Commission to work on problems involved in the use of international regulation to raise and sustain useful production from the sea.

When the Food and Agriculture Organization of the United Nations was established, it recognized the integral relation between fisheries and other sources of the world's food by including a fisheries division in its organization. The FAO sponsored fisheries councils for the Mediterranean and the Indo-Pacific regions, provided technical assistance in support of the development work of individual governments and launched a broad project for the thorough mapping of the world's resources, including the resources of the sea.

2. *Inland fishery and fish culture*

Fish taken from inland waters amounted at mid-century to some 18 per cent of the world's total fish catch and to as much as 30–40 per cent of the fish

actually consumed as human food. Three-quarters of the freshwater fish production was in Asia. Fish were taken from lakes, ponds, rice paddies and other limited bodies of water under more nearly controlled conditions than were possible in deep-sea fisheries.

Regulation of freshwater fishing and public measures to sustain or improve the supply of fish were widespread, especially in Europe and North America. Programmes to control soil erosion which required the construction of ponds to impound waters also included the aspect of fish production. At the same time the dumping of industrial wastes which destroyed the fish in rivers became an increasingly serious problem in some areas. The conservation policies of countries in these regions were based on the results of continuous studies of fish habits, of how to maintain a balance between predacious and non-predacious species, of fish hatchery management and of sound procedures for stocking waters with young fish. These programmes were concerned to a considerable extent with maintaining fishing as a sport and only partly with freshwater fish as a source of food, except in the case of farm ponds.

In Asia, on the other hand, much freshwater fish was directly raised for food, especially in China, Japan, Cambodia, Indonesia, Thailand, Malaya, the Philippines and India, all of which areas had well-developed traditions of fish culture. In these countries and in other parts of the world fish culture was related with agriculture in a single complex. Swamp lands unsuitable for agriculture might be converted into productive areas by drainage and the development of fishponds, as had been done in Java, the Yangtze valley and along the Adriatic coast. Irrigation systems offered opportunities for fish culture, although they also presented problems such as the need to provide fish ladders at dams to permit some types of fish to reach their upstream spawning grounds. Fish culture might be combined with animal husbandry, as was done by the Chinese who used methods for draining animal waste into fishponds to fertilize the plankton on which the fish fed and to stimulate the growth of aquatic plants for animal fodder and grass for grazing along the margins of the ponds.

Because of the importance of fish as a source of protein in areas where nutritional levels were low and other sources scarce, research was conducted in many places into means of improving the efficiency of fish culture and raising output. Where it could be developed, fish culture offered possibilities for very much larger production of animal protein per acre than did animal husbandry. Fishpond culture, moreover, yielded much greater production per surface area of water than did fishing in natural water.

Fish farming in ricefields, long practised in Asian countries, was greatly developed during these years through experiments in fish types and culture methods. In Indonesia the practice of stocking the flooded ricefields with large numbers of fish, primarily with carp before the second world war and thereafter with particularly prolific types such as the African tilapia, led to high yields. The Japanese planted special strains of rice which flourished under

conditions that were also favourable for fish, and they achieved an extremely productive, balanced rice-and-fish economy. In India the government encouraged fish culture in the ricefields by the free distribution of fish for stocking, when studies showed that the principal varieties of Indian carp grew faster in rice paddies than in ponds. Evidence from Indonesia, China, Japan and Malaya, moreover, indicated that fish culture, besides providing an additional source of income to the rice farmer, actually increased the yield of rice by from 6 to 15 per cent, since the fish ate weeds and insects injurious to the rice and fertilized the plants.

The development of fish culture was also closely related with measures of public health. As a means of purifying sewage, it was of major importance in countries such as China, where an estimated quarter to a third of all deaths were attributable to disease borne by night-soil used as manure, or in Java where sewage water was found to contain large quantities of typhoid bacteria. Purification of sewage water by means of sewage fishponds proved effective in rendering sewage water safe for irrigation while producing large yields of fish which could be safely eaten.

Recognition of the role played by mosquitoes in transmitting malaria, filariasis, yellow fever and dengue led to the development of cultural practices designed to eliminate this menace, and their application in many regions of infestation. The stocking of waters where mosquitoes breed with species of fish which feed on mosquito larvae and the rearing of plantfeeding species to keep ponds free of the vegetation in which mosquitoes breed were found to give the best guarantees of continuous improvement. Efforts to control the small snail which acts as host for the parasites causing bilharzia in Africa, South America and China led to successful experiments in East Africa and the Belgian Congo in stocking infested waters with plant-eating fish to control the food on which the herbivorous snails depend and with mollusc-eating species of fish to devour the snails directly. Biological control of disease vectors and carriers was still in its infancy at mid-century, but there were indications that research into fish species and culture methods would bring significant results for the sanitation of water areas.

V. NUTRITION

In the middle of the twentieth century, the British Ministry of Health declared that 'nutrition is the very essence and basis of national health'.* The dean of American nutritionists, Dr Henry C. Sherman, reviewing fifty years of scientific work in many laboratories, concluded that nutritional knowledge now made it possible to increase the health and efficiency even of those who were already healthy and efficient and to add extra years, not simply to old age but to the prime of life. He aptly titled his review *The Nutritional Improvement of Life* (New York, 1950).

* Quoted in Henry C. Sherman, *The Nutritional Improvement of Life* (New York, Columbia University Press, 1950), p. 8.

The science of nutrition on which these claims were based was a twentieth-century development, though it rested on many earlier studies in chemistry and physiology. From small efforts in the early years of the century it grew with great rapidity, gaining momentum and proliferating in many directions. By the 1930s the new knowledge was entering into public consciousness and public policy. The stimulus of the second world war with its pressures for survival brought further advances in both knowledge and public understanding.

As a body of scientific knowledge, nutrition was unique both in having a direct and immediate bearing on the life and welfare of each individual, and in depending for its application upon the conscious choice or established habit of all the people. That choice was limited by the individual's resources, and where these were insufficient to ward off hunger nutritional knowledge could not solve the basic problem, yet even at low dietary levels it could make a substantial difference. Although it provided an instrument for agricultural policy, medical practice and social welfare, its effective application required widespread understanding and acceptance by every family, not merely by the scientist and technician. As Dr Sherman expressed it, 'nutrition is everyone's adventure'.*

The groundwork for the twentieth-century science of nutrition was laid in the work of nineteenth-century European chemists and physiologists who identified major food components—proteins, fats, carbohydrates—studied processes of digestion and respiration, devised methods of measuring bodily intake and output of certain chemicals, and experimented on a variety of laboratory animals to establish conditions under which they could not survive. Feeding experiments on farm animals, undertaken in the agricultural experiment stations established in Britain, the United States and some of the European countries from the middle of the nineteenth century, set the pattern for many developments in which the quest for healthier and more productive animals threw light on the needs of healthier humans.

As the science of nutrition developed, it covered an ever-widening field. Starting with the overall problem of the conversion of food into energy, it brought into the focus of investigation the protein component, minerals and the newly discovered vitamins. By the 1930s knowledge of energy, proteins, minerals and vitamins was sufficient to provide a general guide to good nutritional practice, but a continuing process of discovery and refinement brought constant elaboration and revision of concepts and standards. New research techniques became possible through developments in many of the sciences, including electronic instruments for more exact measurement, techniques of microbiology which permitted the use of bacteria, moulds and other micro-organisms as subjects of study in place of animals with longer life-cycles, and the use of radioactive isotopes to trace the course of specific nutrients through the system.

* H. C. Sharman, *op. cit.*, p. 9.

1. *Food as a source of energy*

Food was first studied systematically as a source of energy. Beginning in the 1890s new laboratory methods for measuring the conversion of food into energy were used to determine the rate of conversion, the ability of the body to store energy, the manner in which it maintains energy levels and the effects of energy depletion. Out of these studies came a basis for calculating requirements in terms of calories—units of energy-giving food—in relation to body size and energy expenditure.

Calorie requirements had still not been fully explored by 1950, however, when the FAO undertook to formulate them in terms which would be applicable internationally. Requirements in relation to body weight for a 'representative' man and woman engaged in 'normal' activity and for children of different ages, all living in the temperate zone, could be stated on the basis of a substantial body of scientific evidence, as could the additional needs of women during pregnancy and lactation. But the increases or decreases indicated in the FAO standard to take account of older ages, hotter or colder climate and greater or less activity were based on much more fragmentary evidence.

In offering its guide the FAO noted that research was still needed to validate or modify its assumptions, including assumptions as to the constancy of the weight-calorie relationship in different areas and cultures and the decline of requirements in direct relation to age, warmer temperature and lesser activity, as well as the assumption that these are independent variables. It called attention to the need for more knowledge of the requirements of adolescents, of the effects of taking in the same total of calories but in different forms, and of what would constitute 'optimal' nutrition and not mere sufficiency.*

2. *Protein requirements*

Studies of the protein component of the human diet were initiated in the early years of the century in the attempt to establish the amount of protein needed and how far this might be reduced without damage. Subsequent investigations kept this question alive, and at mid-century it was still open to difference of opinion. The broad question of amount, however, had been replaced by the more important question of which of the several amino acids yielded by proteins were essential and in what quantities. Several of the amino acids had been isolated in the nineteenth century, but it was not until the 1930s that the importance of each was tested and the broad concept of protein requirement effectively broken down. This remained one of the most important and still incomplete areas of research. Although at least eight distinct amino acids had been identified as essential, and quantitative require-

* *Calorie Requirements: Report of the Committee on Calorie Requirements*, FAO Nutritional Studies no. 5 (Washington, D.C., June, 1950).

ments for some had been worked out, nutritional guides continued to state protein requirements as a whole.*

3. *Mineral requirements*

The importance of certain of the minerals was recognized in the nineteenth century, notably calcium for the formation of bone, iron for the treatment of anaemia and iodine to prevent goitre, but these and other inorganic substances were regarded as specific medicines to treat disease rather than as essential nutrients in normal life. In the early twentieth century specific studies of calcium requirements revealed their great importance for growing children and pregnant women and stimulated the consumption of milk. Infant milk stations, which had been established by philanthropic efforts in the poor districts of some cities as a means of relief and to reduce infant mortality, became centres for nutrition education where the need for adequate milk consumption was impressed upon the mother. Later studies of the calcium requirements of adults indicated the possible value of generous supplies of this mineral for adults as well as children, but at mid-century this was another of the open questions requiring further research. The mounting evidence of the value of milk as a source of other nutrients, however, led to a constant increase in its consumption and thereby to a tendency toward greater calcium intake.

When iron was recognized as an essential element, not merely as a therapeutic drug, and its presence in green vegetables was detected, a second major class of 'protective' foods, leafy vegetables, was brought to public attention even before the full value of green vegetables for other nutrients became known. Every child in the United States who attended the movies or read the comic strips became familiar with a comic character, Popeye the Sailor, who fortified himself with one of the leafy vegetables, spinach, before performing prodigious feats of strength, and spinach became a household byword as the symbol of a healthy diet.

The general need for iodine was established in 1921 by a mass experiment on school children in an area where goitre was endemic (Akron, Ohio), and thereafter the general practice of iodizing salt eliminated this once familiar evidence of dietary deficiency. Other minerals which were successively recognized as essential were generally found to be present in sufficient amounts if other dietary requirements were met, but the possible need for minute quantities of trace elements comparable to those found to be essential for plant nutrition focused research at mid-century on these less conspicuous but potentially vital minerals.

4. *Vitamins*

The revolutionary developments in nutrition in the twentieth century, however, involved the elusive substances which came to be known as vitamins

* *Recommended Dietary Allowances, Revised* 1953. National Academy of Sciences—National Research Council. Publication 302 (Washington, D C., 1953).

and whose identity and specific effects were gradually and continually unfolded during these years.

Although the deficiency disease, scurvy, once the curse of sailors on long trips, had been controlled for a hundred years by means of fresh fruit, the reason for this success was not known. At the turn of the century, studies in Indonesia by the Dutch scientists, Christien Eijkman (1858–1930) and G. Grijns (1865–1944) and other studies in Japan, revealed that beriberi, a deficiency disease prevalent among populations living on polished rice, could be checked if the grain husks were also consumed. From these observations the idea began to develop that the lack of specific factors produced a qualitative deficiency in the diet.

The existence of some substance or substances essential to normal growth and the prevention of deficiency diseases was established in a Cambridge University laboratory in 1906, and in 1912 the term 'vitamin', introduced by the Polish chemist Casimir Funk (1884–), was adopted for this unknown element. The vitamins turned out to be many different substances, each with specific properties whose presence was essential to the health of the organism. By mid-century fifteen or more groups of vitamins had been identified and research was continuing to uncover elements not previously detected.

Research into vitamins proceeded simultaneously along two lines; the existence of each vitamin was inferred, its effects noted and its presence in different foods was determined before it was physically isolated and chemically identified. Although the principal vitamins were the subject of intensive study, and their existence, general function and presence in certain foods became a matter of public knowledge in the first quarter of the century, they were not identified chemically until the 1930s. Once the chemical composition was known more precise experiments could be carried on and synthetic vitamins could be administered therapeutically or used as a food supplement to avoid dietary deficiences.

Initially the emphasis in vitamin research was on their role in the control of acute deficiency diseases—scurvy (vitamin C, in citrus fruit), beriberi (vitamin B_1, thiamine, in whole meal), pellagra (vitamin B_3, niacin, in milk, greens), and rickets (vitamin D, in fish-liver oil, sunshine). The prevention of nutritional disease continued to be a principal goal.

It soon became apparent, however, that vitamin inadequacy could reduce efficiency long before it produced symptoms of disease and that some vitamins might never show their lack in disease but only in poor growth and vigour. The focus of much research shifted from how to prevent disease to how to ensure positive health. Studies on many generations of rats, for example, all maintained in health but fed diets with different quantities of vitamins, showed statistically significant differences in many respects: rate and amount of growth, age of maturity, fecundity, ability to rear healthy offspring, signs of ageing, and longevity. Such experiments made it apparent that knowledge

of nutrition offered a tool which could be used to effect very marked modifications in the quality, vigour and length of life.

At mid-century knowledge of vitamins was sufficient to permit the formulation of a general guide to sound nutritional practices. Especially for the temperate zones where most of the research had been conducted, and in relation to dietary patterns prevalent in those areas, normal nutritional needs for the major vitamins had been established with sufficient authority to provide benchmarks for the housewife, mother, institutional director or public official responsible for rationing or agricultural planning, and to offer a basis for dietary surveys of population groups to evaluate the relation of existing dietary patterns to what would be presumed to be adequate levels. Yet much remained to be learned. Additional substances with specific nutritional effects were constantly being detected. Though much was known about minimum requirements, great uncertainty continued as to the optimal amounts, i.e. how much more than that needed for balance could advantageously be absorbed and with what results. Knowledge of nutritional needs under tropical conditions and in relation to diets found in those regions remained very incomplete.

5. *Nutritional value of specific foods*

Translation of nutritional principles into practice depended upon knowledge of how the necessary nutrients could be secured from particular foods. By the 1920s the major foods from which the principal nutrients could be derived had been recognized; as additional nutrients were identified they were generally found to be present in the same foods. Although some forty essential nutrients were known by mid-century and the search for more was continuing, practical programmes of nutritional improvement could be focused on relatively few elements, since foods which contained these could ordinarily be counted on to furnish sufficient amounts of the others. Emphasis on milk, green vegetables and fruits as protective foods continued, and the importance of adequate sources of protein was stressed. With later analysis of protein factors, however, crucial difference between those derived from animal and vegetable sources became apparent. In view of the needs of areas where land resources or dietary habits made the provision of animal protein most difficult intensive investigations into alternative sources were conducted. The protein supplied by soya beans and groundnuts was found to approximate that from animal sources and to contain properties which were lacking in grains. Fish culture also offered an important protein source in these areas.

In order to provide a guide which the housewife could follow, daily requirements were formulated in terms of foods which would furnish the necessary nutrients. In the United States, for example, daily servings from each of seven groups of foods were recommended. For other regions standard

dietary patterns were necessarily adapted to different food preferences and to local food supplies.

6. *Use of nutrients by body*

Since nutrition is not simply a matter of nutrients but of their total role in the living organism it was essential to understand their interrelationship, possible factors which might impede their use, their effect on the dynamic balance of the body, and their relation to processes of growth, recuperation and degeneration and to disease or injury.

The interrelations among nutritional requirements led to immense complications in nutritional research, since not only the individual components but their many possible combinations had to be explored. As elements were more clearly identified it became possible to examine these interrelations more precisely. The dietary requirements of the vitamin niacin, necessary to prevent pellagra, for example, had to be modified when it was found that niacin could be formed from a specific amino acid if it was present in sufficient quantity. Certain substances present in some foods, moreover, were found to block the operation of particular vitamins and to create conditions of deficiency. On the other hand some of the antibiotics appeared to permit the organism to make fuller use of available nutrients and resulted in improvement in growth when fed to young animals.

The fundamental concept that a whole organism is more than the sum of its parts, furthermore, plagued all such research by calling into question the results of observations made with synthetic elements removed from their natural context. In practical application this led to a long conflict, still unresolved at mid-century, between those who thought that nutritional adequacy could be achieved by supplementing dietary deficiencies with a synthetic form of the specific nutrient known to be lacking, and those who held that since all the relationships could not be fully known and reproduced, only the use of natural vegetable and animal products could ensure that the interrelations provided by nature were being maintained. This difference in view found its most vigorous expression in the struggle at the time of the second world war over the use of whole-grain flour as against white flour enriched by the addition of the vitamins known to have been lost in the milling. Whatever the merits of the issue, the enrichment or fortification of bread flour, of margarine with vitamins A and D, milk with vitamin D, and salt with iodine proved a practical means of improving nutrition on a broad scale. Efforts to use similar methods for enriching milled rice, in view of the poorer keeping qualities of unmilled paddy and objections to its taste, met with greater difficulties because of the likelihood that the added substances would be lost in cooking. Fortification of widely used foods produced and distributed commercially continued however to offer one important short-cut to nutritional improvement.

As nutritional studies were extended from problems of preventing de-

ficiency to possibilities for positive improvement they led to a revision of traditional assumptions about the fixity of bodily characteristics and such notions as that differences in size between upper- and lower-class populations reflected differences in racial origin. Studies of laboratory animals indicated that nutritional adequacy might differentiate individuals of common heredity and have the effect of raising what had been presumed to be hereditarily determined limits. Experimental feeding of numbers of children living in institutions in England and Scotland resulted in marked differences in physical and mental development, for which no genetic explanation was plausible, between those who received and those who lacked milk supplements to their diets. Such studies, combined with new insights into the dynamic processes of constant change and mutual adjustment of body constituents, revealed a much wider range of potentialities and much greater flexibility than had been assumed, and made nutrition appear as an instrument for positive human development. When the average height of second world war recruits in several countries was found to be well above that of the first world war, and similar evidence was reported in the United States for succeeding generations of university students, the possibility that improved nutrition might affect the characteristics of whole populations appeared to be more than an hypothesis. Experience with school lunch programmes indicated that the effects could be mental as well as physical.

A vital aspect of nutrition study related to the rate at which nutrients were used, the frequency with which they must be supplied, what resources the body could store and what capacity it had for recuperation when its needs had not been met. The early preoccupation with deficiency diseases and work on the needs of children for proper growth and development led directly to the question of how permanent was damage suffered in childhood or by reason of severe deficiency. While the need of a continuous supply of many elements was established, such far-reaching studies as *The Biology of Human Starvation* (by Ancel Keys and others, Minneapolis, 1950) revealed the human body's capacity for nutritional recuperation and the mechanisms by which this was brought about. Other studies of the effect on nutritional requirements of febrile diseases, surgery and shock, and of the relation of nutritional status to the healing of wounds and other regenerative processes made the manipulation of nutritional factors an important therapeutic tool in the hands of the medical profession.

Toward the middle of the century attention began to be focused on the role of nutrition in the process of ageing and the maintenance of the vigour of life. For the first time, in 1953, the revised edition of the *Recommended Dietary Allowances* issued by the National Research Council in the United States included a differential for age of adults, as the results of the first studies on the relation of diet to ageing began to become available. Nutritional research became an integral part of studies of chronic and degenerative diseases, notably heart disease, hypertension and cancer. Mounting evidence

of a relation between certain body fats and certain conditions of the heart stimulated investigation into the role of fats and carbohydrates which had remained largely unexplored while the basic knowledge of vitamins, minerals and proteins was being developed. The National Research Council in 1953, however, continued to omit these substances from its table of recommended allowances, noting that the state of knowledge was still too limited to permit recommendations for either fats or carbohydrates.

7. *Dissemination of nutritional knowledge*

Application of nutritional knowledge in practice depended upon its widespread dissemination in a usable form, on the availability of necessary foods, and on food habits and the willingness of people to change their dietary patterns. Public policies played some part in raising nutritional levels, although in the last analysis nutrition rested on the daily actions of all the people.

By the 1920s, the new knowledge of nutrition was beginning to reach the public. Evidences of physical defects among military recruits in the first world war focused public attention on the problem of nutritional status as a factor in national health. The simultaneous discovery of vitamins pointed the direction for action. The child health movement quickly incorporated the new knowledge.

Nutrition-consciousness reached the public through the press, where the women's pages offered their readers information concerning the calorie content and nutritional values of recipes which they published and suggested ways to plan balanced meals. Advertisers of certain foods such as milk stressed their nutritional properties. When synthetic vitamins became available, their producers spared no effort in informing the public of their value. Knowledge of nutrition spread through educational channels. The first university professorship in nutrition in the United States was established in 1921 at Columbia University in New York, and the subject was introduced into the curricula of schools and colleges in the following years.

One of the major means of spreading knowledge and also of affecting nutritional levels directly was school feeding. From the middle of the nineteenth century the provision of school meals for destitute children and for those who by reason of distance from home would otherwise be unable to attend school had been a favourite form of private charity in many countries where the extension of elementary education was bringing poor and hungry children into the schools. In the 1920s these measures for the relief of hunger began to be converted into means of ensuring that all children should receive the right kind of food, since it had become clear that a large proportion of children suffered from improper diets even when they had enough to eat. The 'Oslo breakfast', designed in Norway to provide protective foods and to make up for likely deficiencies in home diets, became the prototype for school feeding programmes in many countries. Evidence from Oslo and elsewhere

that the provision of such foods not only affected the children's health but their alertness and ability to learn made good nutrition a tool of education and increased the popularity of school feeding as a means of spreading nutritional knowledge and habits to the general public.

Countries differed considerably in the manner in which they used the school lunch device. The Netherlands for example, one of the first countries to make public provision for school meals for children who otherwise would be unable to attend school, considered school feeding as an encroachment on the normal domain of the family and provided only milk, using school lunches primarily for emergency situations or in cases of extreme need. Britain on the other hand made school milk and school lunches part of its general national health plan, available to all. In the United States a programme which started in the 1930s as a means of disposing of surplus agricultural products developed into a broad programme of federal aid in which schools and local jurisdictions received federal funds only if they met established nutritional standards and made meals available to all children, without cost to those who could not pay. In some countries, notably Israel, older children learned nutritional practices by preparing the school lunch. Elsewhere, as in Puerto Rico, the participation of mothers' groups in school meal preparation served as a means of introducing the mothers to the nutritional ideas on which the lunches were based.

School lunches, however, were only one of the many organized channels through which nutritional knowledge reached the public, especially mothers. Maternal and infant health services took advantage of the eagerness of mothers to accept new knowledge for the benefit of the child. Day nurseries, day care centres and kindergartens demonstrated the uses of milk, fish-liver oil and fruit juices. In a number of countries milk stations for infants and pre-school children were supported by public funds and community effort. From the 1930s on, every mother who came in contact with virtually any programme of child health, education or recreation found herself exposed to ideas of sound nutrition and to pressures to conform.

The relatively small impairment of health in the countries most hard hit by the depression of the 1930s was attributed to the efforts of families, even on sharply reduced budgets, to include the protective foods whose importance they had learned. The publication by the United States Department of Agriculture in 1933 of *Diets at Four Levels of Nutritive Value and Cost* provided a guide which showed that, above a reasonable minimum income, an adequate diet could be provided at costs consistent with lower as well as higher income levels. Intensive nutrition campaigns during the second world war, which made good practices a patriotic duty, left a strong residue of nutrition-consciousness when wartime austerity was past.

8. *International concern with nutrition*

Nutrition was recognized as a matter of world concern with the establishment of the League of Nations Mixed Committee in 1935. When the United

Nations FAO was established in 1945, international efforts to develop world food supplies received a strong nutritional orientation. FAO's estimates of world food needs, and its technical assistance in relation to the world's food resources, were based upon the concept of food as nutrition; they directed attention and effort to the production and distribution of those foods most needed to raise or maintain nutritional levels. FAO's first world food survey in 1946 pointed out that in order to meet current standards for good nutritional status, world production of fruits and vegetables would have to be raised 163 per cent above pre-war levels, milk 100 per cent, pulses and nuts 80 per cent, as against only 12–34 per cent for sugar, cereals, tubers, fats and oils. In the light of the accumulated evidence that milk could make the most crucial difference in child health, the United Nations Emergency Children's Fund (UNICEF) devoted the major part of its programmes around the world to the provision of milk through direct distribution, the development of milk drying facilities, and educational programmes around its use.

At mid-century the science of nutrition and the application of nutritional knowledge were still far from their goals. Not only was there much to be learned concerning nutritional requirements and how they might be met, but in vast regions of the world existing knowledge was still poorly applied. In much of Asia and parts of Africa total food supplies failed to provide sufficient calories and proteins, and hunger remained widespread. Good nutrition on a mass scale depended on overall economic and social conditions as well as on education; poverty barred many from its benefits and ignorance or apathy barred many more, not only where supplies were scarce and poverty widespread but in countries where food was plentiful. Yet the application of the new knowledge had already brought spectacular results, people throughout the world were becoming aware of basic nutritional principles, and public policy was directed toward the goals of human health and vigour which the science of nutrition held out.

VI. INTERNATIONAL MEASURES FOR FOOD AND AGRICULTURE

The need for international action relating to both technical and economic aspects of food and agriculture had been recognized before the end of the nineteenth century. Specialists in many fields, chiefly from European countries, held international technical meetings, such as the first International Veterinary Congress in Hamburg in 1863, a Congress of European Forest Experiment Stations and Research Organizations at Namur in 1883, an Hydrographers' Congress on marine life in the Baltic and North Atlantic in 1893, and conferences on various phases of agriculture, horticulture, viticulture, pisciculture, dairying, plant and animal breeding, plant and animal diseases and meteorology. Economic aspects were first approached internationally in 1864 when Great Britain, France, the Netherlands and Belgium attempted unsuccessfully to control export subsidies for sugar by means of

an international convention. The severe agricultural depression of the 1880s and 1890s led to the formation in 1889 of an International Commission of Agriculture to study ways to offset the inherent economic weaknesses of agriculture.

In 1905 a permanent intergovernmental organization, the International Institute of Agriculture, was established in Rome. Its initiator, David Lubin (1849–1919), recognized the farmers' disabilities in acquiring technical knowledge and their weak economic bargaining position, and was able to persuade governments that this situation could not be wholly amended by measures limited to single countries. The Institute initiated joint action by governments on such matters as pest and disease control; it laid the groundwork for viewing agriculture on a world-wide basis by securing the adoption of procedures which would permit the international compilation and comparison of agriculture data, such as standard nomenclature for classification of soils and standard weights and measures for reporting agricultural statistics; it instituted a number of yearbooks and monthly bulletins on agricultural legislation, agricultural statistics, forestry statistics, agricultural science and practice, agricultural economics and sociology, plant protection; it prepared technical monographs on many specific subjects. Since support for the International Institute of Agriculture was chiefly European, its materials and studies dealt mainly with this area and did not include the underdeveloped sectors of the world.

The work of the International Institute of Agriculture was focused on production. Prior to the 1930s there were no general statistics of food consumption and few family budget studies had been made; nutrition was still mainly a laboratory science. But when the League of Nations entered the agriculture picture in the 1930s it was through a concern with consumption—'food' rather than 'agriculture'. The 1937 report of the League's Mixed Committee on the Problem of Nutrition showing the prevalance of malnutrition in economically advanced countries stimulated some twenty governments to set up national nutrition committees and to begin to formulate their national policies in relation to the consumption as well as the production of food. When the second world war converted surpluses into shortages, nutrition committees played a major part in the rationing of supplies in relation to nutritional needs, and international techniques were developed among the allied powers for allocating scarce food and raw materials.

The Food and Agriculture Organization was projected during the war at the Hot Springs (USA) conference in 1943 and created at Quebec, Canada, in 1945 as the first of the new United Nations' agencies. It drew its inspiration and basis of operation from three sources: the groundwork of information and co-operation built up by the International Institute of Agriculture; the League of Nations' concern with nutrition; and the wartime demonstration in Canada and the United States that the application of science could bring as spectacular results in agriculture as in industry, leading these countries to

believe that their experience could be applied with dramatic effect to the remaking of agriculture in other parts of the world. The organization as set up included divisions of agriculture, forestry, fisheries and nutrition.

The objectives as stated in the preamble to the constitution of the Food and Agriculture Organization were:

raising levels of nutrition and standards of living . . . , securing improvements in the efficiency of the production and distribution of all food and agricultural products, bettering the condition of rural populations, and thus contributing toward an expanding world economy.

As the Canadian chairman of the first session of the FAO conference, Lester B. Pearson, pointed out, FAO was the first international organization to set out 'with so bold an aim as that of helping nations to achieve freedom from want'.

The first director-general, Sir John Boyd-Orr, envisaged the organization as providing a world-wide mechanism for enabling supplies which could be produced to reach people who needed them, and he proposed a world food board for this purpose. During the immediate post-war years when shortages were acute, an International Emergency Food Council performed such a function. But as European agriculture recovered and shortages quickly turned again into surpluses, the idea of a world food board was rejected, because of the difficulty of making surpluses available to hungry groups in other countries without disrupting the normal trade in agricultural products within the country and compounding difficulties in the international balance of payments.

The problem of hunger in the face of plenty appeared inseparable from the broader problem of poverty and low productivity in much of the world. National efforts to adjust agricultural production and sustain farm incomes, moreover, were in themselves obstacles to international measures with the same objectives.

Only in the case of dried milk was a means found through the work of the United Nations Emergency Children's Fund to make surplus supplies in large volume available to the world's undernourished children. For the rest, emergency grants in case of threatened famine or other disaster remained the main international machinery for directing surplus agricultural products to needs during the 1950s.

Nevertheless, the issue of the relation of the world's food-producing capacity to the world's food needs received increasing attention as very rapid rates of population growth in the decade after the second world war raised questions as to the adequacy of food supplies for the future. In the debate which went on during these years, the director-general of the FAO, Norris Dodd, stressed the possibilities for international effort which had not begun

to be tapped. 'We will not give up to hunger . . .' he declared, 'until we have tried everything we can think of. We haven't done that yet even on a small scale, let alone all over the world, all together.'*

As the FAO developed its international programmes it veered more and more toward a type of activity which had not formed part of the international thinking in the field of agriculture in the earlier period, and which had not been at the centre of planning when the FAO was formed, namely technical assistance to underdeveloped areas to bring to them the techniques which had given the agriculturally advanced countries their high level of productivity.

The League of Nations Mixed Committee on Nutrition had included no one from Asia, the Near East or Africa among its twenty-one members and only one from Latin America. Neither the League nor the International Institute of Agriculture had been concerned with the low level of nutrition and low productivity of agriculture in underdeveloped areas. Participation in the formation of the FAO was somewhat broader than in its predecessor organizations, but it was not until after 1947, when numbers of newly established countries became members of the international organization, that the focus of international effort in the field of agriculture began to shift toward the underdeveloped sector of the world.

Pressure in the newly developing countries to speed up development and their requests for international aid in this process made technical assistance, by the mid-1950s, a principal function of the FAO. Considerable international assistance in food and agriculture also reached these countries through such other channels as the Colombo plan and the technical assistance programme of the USA.

The FAO was called upon to assist countries around the world in a great variety of ways. Some indication of the range of approaches and of the interests common to a number of countries may be found in the training institutes held on a regional basis for representatives from a number of countries, under FAO auspices, in the years 1950–55. Within this five-year period ten regional institutes were held on agricultural censuses and other statistics and five each on agricultural extension, fisheries and fish culture, forestry and forest products. Seminars on the formulation of development projects were held in three regions. Two institutes were conducted on rice culture and grading, on dairying, on pasture and range, on disease control, on nutrition and on co-operative organization and one each on land problems, agricultural credit, rural electrification and rural welfare. Two-fifths of these training programmes were held in Latin America, a quarter in Asia and a fifth in the Near East and Africa.

Extensive though these activities were, they made only a beginning towards resolving the long-standing and intractable problems of the world's food and agriculture. The momentum of technical progress, moreover, constantly tended to widen the gap between the technically advanced and the under-

* Quoted in P. Lamartine Yates, *So Bold an Aim* (FAO, Rome, 1955), p. 65.

developed areas. Reviewing the world state of food and agriculture in 1955, the FAO concluded: 'Continued advances in technical methods no less rapid and fundamental than those of the past decade may be expected in the years immediately ahead. But the extent to which they can be utilized will depend to an increasing extent on the success with which the economic and social problems of agriculture can be resolved.'*

NOTES TO CHAPTER XIV

1. Professors R. I. Stolper and A. M. Gurevich consider that the Author-Editors have not brought out sufficiently the difficulties which the Soviets have met in collectivizing agriculture and in achieving high levels of agricultural productivity where agriculture has been collectivized. Non-communist experts in agricultural economics and rural sociology maintain that this field of endeavour is not susceptible of the kinds of organization appropriate to industry and that the agricultural population cannot be transformed into the social type of the industrial proletariat. They argue that agriculture is a highly diversified occupation requiring the individual to make daily decisions based upon close observation of plants, animals, soil, weather, etc., to command a variety of knowledge and skills, to plan and manage a changing series of processes, to meet frequent emergencies, and to be responsible, under conditions which often defy close supervision, for tools, machinery, supplies, buildings, animals and harvested crops. Some farms producing a single crop such as grain or sugar may be operated after the manner of a grain or sugar factory; but diversified agriculture requires the kind of responsibility and attention that do not appear to be consistent with collectivization.

   The evidence upon which these writers base their judgment is twofold: (1) the great success and productivity of family-type farming in such countries as Holland, Denmark, the United States, Canada, and New Zealand, and (2) the record of the Soviet Union's search for a way to transform peasant farming into state or collective farming while increasing the production of agriculture necessary for the success of the entire communist objective. The government's first efforts at thorough collectivization were met by peasant resistance—refusal to work on the collectivized farms, slaughter of animals and destruction of products which were to be delivered to the state. The policy of steering peasants into collectivism by establishing tractor stations where farm equipment was concentrated for cultivating the land in the large masses of the collectivized farms worked fairly well for crops which could use large machinery. Farm workers, i.e. ex-peasants, however, still found little satisfaction as an agricultural proletariat working upon a large-scale farm. In the 1930s the Soviet government permitted the peasants to have a small plot of land, a few animals and some poultry, which they and their families could tend while being employed as well on the collective farm. Within a short time the peasants were producing on their plots much of the food available to the consuming public. This system had two major defects from the Soviet point of view: it led the peasant to neglect work on the collective farm in favour of his private plot; it tended to preserve a sense of private property and thereby to obstruct the drive toward the objective of communism. Although critics have noted that Soviet agriculture has been exploited in order to provide the resources necessary for rapid industrialization, they maintain that this difficulty has not been the central one. They argue that until the Soviets recognize the essential difference between agriculture, which is dependent upon the forces of nature and requires the attention of individuals who can responsibly adjust to these forces, and industry, which is dependent upon man-made machines and requires individuals to operate and control these machines, they will continue to encounter difficulties with this aspect of the economy. These critics take as further evidence the repetition of the difficulties in countries that since World War II

* FAO, *The State of Food and Agriculture, 1955* (Rome, 1955), p. 132.

have come under communist control, where retreat into something comparable to Lenin's New Economic Policy has had to be made. The retreat means that a large measure of peasant farming has been permitted, although collective farming has been retained as the objective.

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Roy D. Laird, *Collective Farming in Russia: A Political Study of the Soviet Kolkhozy* (Lawrence, Kansas, 1958).

Roy D. Laird (ed.), *Soviet Agriculture and Peasant Affairs* (Lawrence, Kansas, 1963).

I. T. Sanders (ed.), *Collectivization of Agriculture in Eastern Europe* (Lexington, Ky., 1958)

D. W. Treadgold, *The Great Siberian Migration* (Princeton, 1957).

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CHAPTER XV

HEALTH AND POPULATION

In perhaps no other area did the application of knowledge during the twentieth century remake the life of mankind more dramatically than in the field of health. While the development of transport, communication and industry radically altered the conditions of life, the application of medical knowledge affected the maintenance and quality of life itself.

In the first half of the twentieth century measures for the protection of health, together with many other improvements in levels of living, nearly doubled the average life expectancy in the technically advanced countries within the space of two generations. The developments of these years all but removed from these countries the prospect of premature death from most of the diseases which had taken the heaviest toll throughout human history, leaving degenerative diseases, man-made hazards and mental illness the major threats to life and health. In the middle years of the century medical knowledge and health practices spread with great vigour to the non-industrialized countries, bringing an even more rapid reduction of mortality in those areas.

The dramatic change in the life expectancy and the health of the people of the world came in two principal directions: the control of communicable diseases which from time immemorial had taken periodic toll in mass epidemics, had constantly threatened the lives of children and had weakened or impaired the vigour of much of the population; and the enormously increased survival rate of the infants that were born.

I. MEDICAL KNOWLEDGE AND HEALTH PRACTICES AT THE OPENING OF THE TWENTIETH CENTURY

At the beginning of the twentieth century the groundwork had been laid for the spectacular reduction of mortality and morbidity that occurred during the next fifty years. Living germs transmitted from person to person, directly or indirectly, were known to be the immediate cause of the principal killing diseases, and during the last two decades of the nineteenth century bacteria producing most of the major diseases had been identified, mosquitoes and other animal vectors had been recognized, and the principle of immunization had been established. The micro-organisms responsible for such diseases as cholera, diphtheria, dysentery, gonorrhoea, meningitis, pneumonia, malaria, plague, tetanus and typhoid fever had been isolated and continuous search was leading toward the discovery of the disease germs for African sleeping sickness, whooping cough, syphilis and others. The mosquitoes which transmitted malaria and yellow fever had been detected in 1897 and 1900 and work

was in progress leading to the identification of the tsetse fly as the carrier of African sleeping sickness and lice as hosts for typhus. The discovery of diphtheria antitoxin in 1890 stimulated the development of other immunizing serums.

Germ theory had been developed and provided the basis for public sanitation and personal hygiene. Antisepsis, widely introduced after the 1870s as a result of the work of Joseph L. Lister (1827–1912), had made possible safe surgery. It had made the hospital an institution for the protection of life and the treatment of disease instead of the centre of infection which it had so often

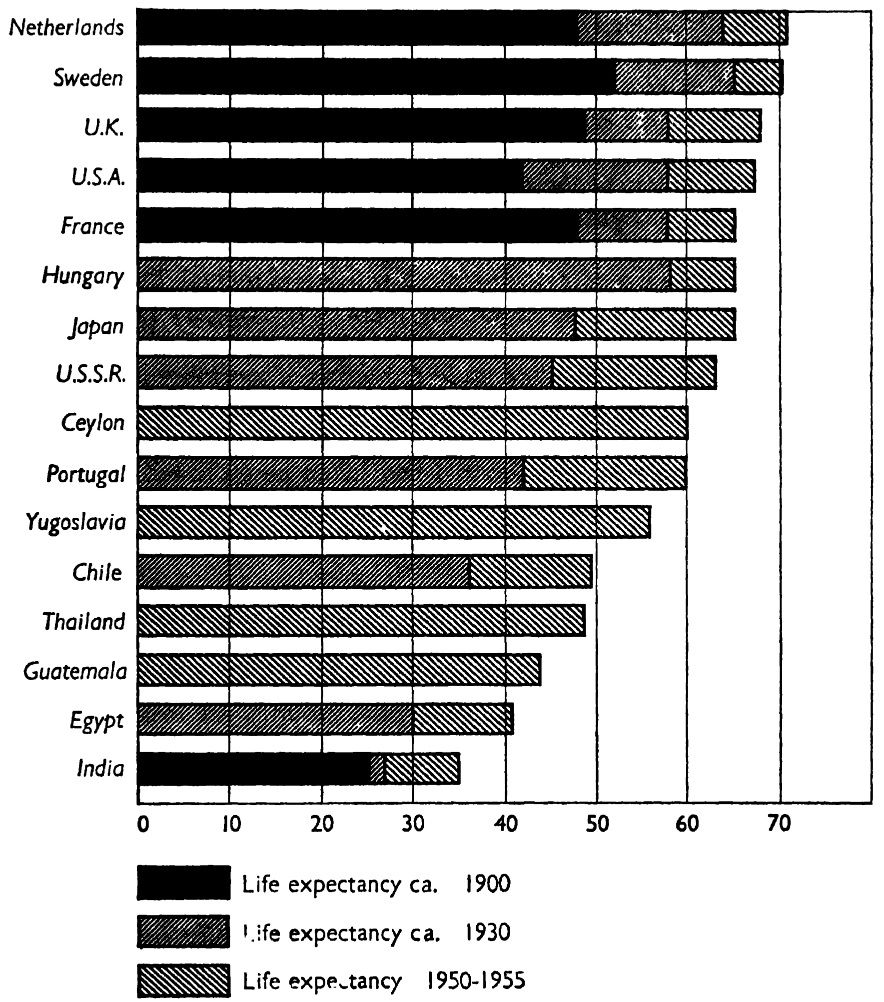

CHART XVI. Life Expectancy at Birth for Males, 1950–55, and Increase since 1900, in Selected Countries.

Source: Woytinsky, *World Population and Production*, pp. 182–8; US *Statistical Abstracts*, 1961.

been prior to the last quarter of the nineteenth century. In the 1890s aseptic practices, designed to prevent the entrance of bacteria into the wound instead of merely combating them, had become the basis of surgical techniques. Basic tools essential for advancement in the treatment, diagnosis and prevention of disease were at hand, such as the X-ray and anaesthetics for surgery.

The concept of public health had been accepted and was reflected in the existence of municipal departments responsible for control of water supply, sewage and refuse disposal, for the maintenance of sanitary conditions in respect to food, housing, and public abattoirs and for quarantine and other measures against communicable disease. Voluntary public health bodies supported public health programmes and educational campaigns against particular threats to health, such as tuberculosis. The first university chair of social medicine was established in Berlin in 1902. The pattern of collaboration among the medical profession, research scientists, government and industry to combat threats to health had become established.

The groundwork had been laid too for a positive attack on the risks of birth and infancy with the establishment in the 1890s of pre-natal clinics and consultation bureaux for infant care. Medical services to school children had been inaugurated in some cities. Paediatrics was a well-developed field of medical specialization.

Several lines of inquiry were under way which were to bear important fruit in the course of the following years: efforts to discover bacteria-destroying drugs, to identify the internal secretions or hormones which maintain or upset the necessary chemical balance of the body, to understand the nature of allergy, and to discover the characteristics of the essential nutrients whose existence had been established experimentally but whose composition was unknown. Mental disorders had begun to be recognized by the public as well as the medical profession as a form of illness rather than punishment for sin, and their identity and origins were being sought.

The basis had also been laid for the fundamental scientific discoveries that were to bring success to these and other medical inquiries, in such developments as the studies of cell structure and pathology, and of metabolic and nutritional processes, some understanding of the nervous system, exploration of psychosomatic relationships, beginnings of blood chemistry and the rediscovery of Mendel's principles of genetics.

There was, moreover, strong institutional support for research in medicine, as well as in the basic natural sciences. University research had been well developed in Germany during the nineteenth century. The Pasteur Institute, established in Paris in 1888 with international subscriptions following Pasteur's successful preventive treatment against rabies, furnished the model for separate research institutes devoted to the isolation and study of disease-producing bacteria, the development of vaccines and sera, and a wide range of physiological and chemical investigations relating to disease.

Before the turn of the century institutions of this character had been

established which continued to serve as major centres for medical discoveries and advances in medical science during the twentieth century: the Russian Institute of Experimental Medicine where Ivan Pavlov carried on his outstanding work in physiology; the British Institute of Preventive Medicine, later known as the Lister Institute, which served not only as a research centre in bacteriology, experimental pathology and biochemistry but as a diagnostic and public health laboratory for the city of London; the Institute for Infectious Diseases in Berlin under the direction of the pioneer bacteriologist, Robert Koch (1843–1910), who had identified the first of the human disease bacilli, anthrax; the Institute for Infectious Diseases in Japan established by Koch's associate Shibasaburo Kitasato (1856–1931), one of the discoverers of tetanus and diphtheria antitoxins and of the plague bacillus; the Institute of Experimental Therapy in Frankfurt, Germany, under another of Koch's associates, Paul Ehrlich (1854–1915), which became a centre for the development and standardization of immunizing vaccines and sera.

French scientists had established Pasteur institutes in Indo-China, Tunis, Algeria and Dakar, while British had founded the Haffkine Institute in Bombay, initially as a plague research laboratory, and an institute in Kuala Lumpur, Malaya, for research in malaria and beriberi. In Latin America, Mexico had set up a National Bacteriological Institute and Brazil had a Bacteriological Institute of Serum Therapy in Rio de Janeiro which later became world-famous as the Instituto Oswaldo Cruz. In the United States, Johns Hopkins University had been founded with the purpose of combining scientific research and teaching in the manner of the German universities and the City of New York had established a municipal bacteriological laboratory which was not only a pioneer in the practical application of bacteriology in the administration of public health but a centre of research in related fields.

At the opening of the century the scientific and institutional bases were thus laid for the strong advances in the prevention and treatment of disease which marked the first half of the twentieth century. Most importantly, health was coming increasingly to be regarded as a matter of science rather than of religion or superstition, and the 'healing art' was finding its basis in 'medical science'. Medicine was being reconstructed from the ground up by the application of the methods of the experimental sciences.

II. CONQUEST OF MAJOR DISEASES AND LENGTHENING OF THE LIFE SPAN IN TECHNICALLY ADVANCED COUNTRIES

In the technically advanced countries during the first half of the twentieth century, all the tendencies noted above were directed simultaneously and with intensified vigour against one after another of the major threats to health and survival. As each principal cause of death and disease was brought under control, the attack shifted to those which had been formerly overshadowed. First the pestilences were conquered, then one after another of the other major

infections; infant deaths were lowered dramatically though a hard core of neo-natal fatalities continued to present a stubborn problem; maternal mortality was reduced more slowly but was finally nearly eliminated. When heart disease and cancer replaced pneumonia, tuberculosis and diarrhoea as the leading causes of death, they became the focus of concern and effort. As success was achieved in ensuring the health of the young, the health of older persons who made up an ever larger part of the population offered the new challenge. Finally, modern society itself brought its new hazards—road and industrial accidents, pollution of the air, radioactivity and the strains of modern life.

1. *Advances in medical science and development of public health*

The great strides in controlling disease and promoting healthy conditions of life were made possible by advances in medical knowledge, the extension of public health principles and practices, and the general economic improvement of the population.

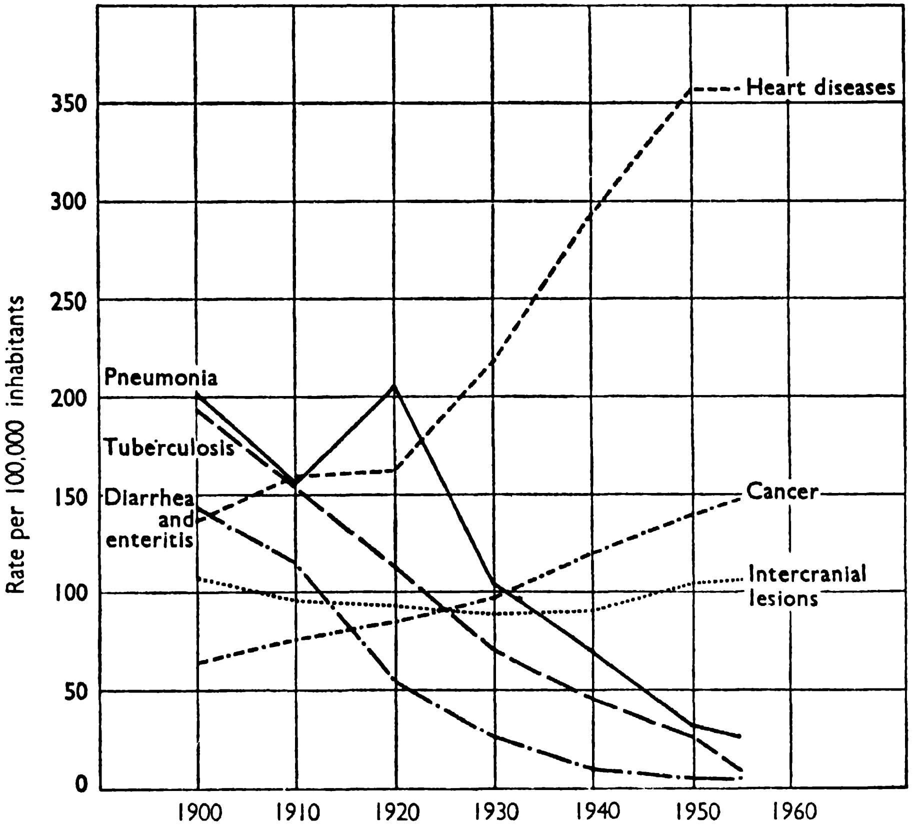

CHART XVII. Deaths in the USA from Principal Causes, 1900–1955.
Source: US Public Health Service, *Vital Statistics of the US.*

Building on the basis of the scientific developments in the previous centuries, medical science pushed forward vigorously; it swiftly incorporated new insights in the basic biological sciences as these were developed, and each advance found almost immediate application in medical practice. The intellectual climate of the twentieth century, the organization of the medical profession, and the public expectation with which medical services were sought all favoured the acceptance of new knowledge and its prompt use to save the lives and mitigate the suffering of mankind.

During these fifty years, medical science made spectacular advances along a number of lines: in the development of vaccines which could be used for immunization against a widening range of diseases; in chemotherapy, with the discovery of the sulpha drugs, the antibiotics, the antihistamines and many others; in endocrinology, with the identification and production of a number of hormones by which internal chemical balance could be maintained or restored; in nutrition; in the control of allergic reactions; in elaborate and delicate surgery, including techniques for the rehabilitation of maimed and crippled and advances in physical medicine; and in the recognition of psychosomatic factors and the diagnosis and treatment of mental illness.

These advances were predicted on two major and complementary theories of disease: the germ theory, i.e. that disease is caused by an invading organism, and the theory of disfunction, i.e. the failure of some part of the immensely complex, interacting physiological system to perform its role in maintaining the normal balance within the body. The germ theory led to the constant effort to identify bacteria or viruses responsible for each disease, to study their habits and characteristics and to find means to destroy or inhibit them both within the body and without. It was apparent however that even the most virulent bacteria and viruses require conditions favourable to their development, since all persons do not develop the disease when these organisms enter their systems. Some disorders, moreover, appeared to arise not from the invasion of an extraneous element but from the insufficient or excessive production in the body of substances essential to normal functioning.

These observations led to the detailed study of physiological and genetic processes, especially of the nature and role of internal secretions and of the information system supplied by the nerves, and to the development of both medical and surgical procedures to affect those processes. To the extent that the balance in the total organism was involved, the patient himself was the object of treatment rather than the invading micro-organism to which he was the host. It became apparent too that the human organism responds not only in terms of its genetic and physiological composition but in terms of its experience, i.e. as a result of conditioning. Medical research was therefore also directed toward understanding the processes of conditioning, both physical and emotional, and to using these processes therapeutically.

The incorporation of advances into medical practice depended upon a broad development of laboratory techniques and facilities, of specialized diagnostic

tools using chemical, electrical, electronic and radiological devices, and of elaborately equipped hospitals to provide expert diagnosis and treatment facilities. It required a high degree of specialization in the medical professions, for with so vast a range of new and ever-changing knowledge the general practitioner could no longer be expected to keep abreast of all developments. It necessitated extensive means of communication through scientific and professional journals, professional organizations and other channels in order that new discoveries might become widely known. It relied upon the development of large-scale industries for the production of drugs, sera and medical equipment on a mass basis for mass use.

Military medicine was often in the vanguard of medical progress. The major wars of the period accelerated the development of medical techniques and their application in many fields, including extensive immunization, the use of new drugs such as penicillin and of life-saving substances such as blood plasma, and the perfection of new surgical techniques and prosthetic devices to permit the recovery and restoration of the physically damaged. Advances which were first registered in the much higher survival and rehabilitation rate of military personnel were later reflected in the health of the general population.

Public responsibility for some matters affecting health had long been traditional, but the public health movement which brought sanitation and health services to the masses of the people in the twentieth century originated in the efforts of civic-minded leaders in the mid-nineteenth century to reform the conditions of the poor. Edwin Chadwick (1800–90) in England and others elsewhere brought to public attention the unhealthy conditions under which the urban working population lived and the threat to the health of all which these conditions produced. Public health measures were undertaken in the second half of the nineteenth century as a part of the movement for better working conditions in factories, shorter hours, reduction of child labour, decent housing and improved living conditions in the slums.

Initially public health was conceived primarily as a matter of public sanitation, and municipal departments of sanitation constituted the core of the public health services. With the requirement that doctors report all cases of specific communicable diseases, immunization against smallpox and further elaboration of quarantine procedures at ports and in communities, public health agencies entered the direct effort to control epidemic diseases. Throughout the period under review, the control, prevention and eradication of communicable diseases remained at the heart of all public health programmes.

With the establishment of maternal and child health services the concept of public health was extended to include measures to prevent forms of illness or death which did not menace the public by reason of contagion. It was broadened still further to make positive health and not merely the prevention of disease a matter of public concern. By mid-century public health pro-

grammes were undertaking to ferret out incipient cases of chronic as well as contagious diseases, to rehabilitate those who were temporarily or permanently disabled by disease or accident and to make available to entire populations every type of protective and curative medical care.

In the last analysis, however, improvement in the economic situation, living conditions and nutrition of the masses of the people must be credited with much of the reduction in mortality and improvement in health. Health surveys repeatedly showed the incidence of all except the degenerative illnesses to be greater among lower economic levels in the population and in sections of cities characterized by congestion and bad housing. Inadequate diets not only meant deficiency diseases in extreme cases but general lack of resistance to such diseases as tuberculosis. Although medical science showed dramatic capacity to raise survival rates in underdeveloped countries in advance of substantial improvement in economic levels and living conditions, the advances achieved in the industrially developed countries during the years under review were intimately bound up with the rising levels of real income enjoyed by the people of these societies.

2. *The control of communicable disease*

(*a*) *Major pestilences: plague, cholera, smallpox.* The great and terrible scourges that had periodically descended upon mankind—plague, cholera, smallpox—had been almost wholly eliminated from western countries by the opening of the century and they were kept out by rigorous measures for quarantine and, in the case of smallpox, immunization. The principal uncontrolled scourge was influenza. The last epidemic of plague to reach Europe occurred around the turn of the century, but it brought no major outbreak and only occasional cases appeared thereafter. Cholera re-entered some of the European ports during the first world war, but the epidemics which had recurred in principal western cities during the nineteenth century were a thing of the past. There were small sporadic outbreaks of smallpox where vaccination was not general.

These diseases were excluded from the West, for the most part, by methods already well-established at the opening of the century. The western countries took the lead in international efforts to prevent their spread by world-wide measures for quarantine and the control of ports and airfields. At mid-century, however, points of infection still existed, especially in south Asia. Plague remained a threat in India, China and Indo-China, though its incidence was being gradually reduced, and sporadic outbreaks continued to occur in parts of Africa and of South America. Cholera, too, remained endemic in south Asia and China. Smallpox broke out from time to time in Asia, Africa and Latin America, and occasionally in Europe or North America.

So long as centres of infection remained, the struggle against these diseases had to go on, through world-wide co-operation to halt every sign of spread and to eliminate remaining sources of infection. When cholera broke out in

Egypt in 1947, supplies of serum were rushed from all over the world and every possible international measure was taken to isolate the epidemic as well as to bring it quickly to an end. The World Health Organization provided technical assistance to India in its intensive effort to control the spread of plague by wild rodents. The regional WHO committee for the European region in 1955 included in its agenda the need for preventive action against smallpox even in the absence of apparent risk. In a world of rapid transport and active travel, eternal vigilance was the price of effective protection.

(*b*) *Principal diseases borne by animal vectors: yellow fever, malaria, typhus and others.* At the opening of the century yellow fever remained a serious threat in many tropical regions, although it was ceasing to invade the temperate areas periodically as it had in the nineteenth century. Malaria was endemic in nearly all tropical and sub-tropical regions and made some areas virtually uninhabitable by reason of its prevalence. Though less lethal than yellow fever, it was a far more serious disease for mankind in its overall effects.

Discovery of some of the mosquito carriers of these diseases around the turn of the century opened the road to their control. Dramatic success in the control of yellow fever by eliminating the mosquito carrier was achieved during the building of the Panama canal after 1900, in an area where earlier attempts to build a canal had been given up in the face of high mortality from this and other diseases. While this success led to the suppression of yellow fever in most areas and its exclusion from urban centres, the hope that it could be completely eradicated had to be abandoned when it was discovered that yellow fever exists among jungle animals. Although the cycle of human patient and animal vector can be broken by preventing the person in an infectious state from being bitten by the carrier mosquito, the possibility remains that the disease may be transmitted to man from jungle animals by jungle mosquitoes. The danger of the recurrence of the disease could therefore not be eliminated in the parts of South and Central America and Africa where it remained endemic.

In malarial regions measures to drain swamps and spread oil on the breeding places of mosquitoes reduced the prevalence of malaria during the first four decades of the century, especially in those areas where the sources of infection were relatively few and where the incidence was not extremely high. Specific drugs, quinine and mepacrine (atabrine), offered a means of treatment and a measure of protection against the severity of the disease. In much of the tropics, however, in Central and South America, Africa and Asia, malaria continued to be ubiquitous and debilitating, deaths from it were numerous and few people in the population of low-lying areas escaped.

During the second world war discovery of the value of DDT, combined with the fact that troops were fighting all over the world in heavily infected malarial areas, led to a spectacular demonstration of what could be done to eradicate the disease. Drastic measures taken by military authorities in regions

where troops were stationed, including the administration of mepacrine to prevent contraction of malaria and the elimination of the mosquito carrier, freed the troops from the danger of the disease. This demonstration of the effectiveness of thorough as against half-way measures led to the adoption of similar tactics by governments in many parts of the world.

Venezuela, where mortality rates from malaria were extremely high and large areas were considered uninhabitable because especially virulent forms of the disease was prevalent, formulated in 1945 the earliest national programme to eliminate malaria completely. Teams equipped with DDT spray visited village after village periodically, spraying all houses inside and out. By eliminating the carrier at the point where it would pick up the infection from an ill person or transmit it to another, this method checked the spread of the disease and reduced its sources. Although mosquitoes continued to breed away from the centres of population, these rarely carried the infection.

Similar measures were put into effect in other parts of the world. The results of these campaigns came rapidly. Italy, which had over 400,000 cases in 1945 had only five primary infections in 1955 and no malaria deaths since 1948. In Ceylon, where more than half the population suffered from malaria in 1940, only one case per 3,000 in the population was reported in 1956.

How long this method of control would remain effective, however, was an open question, for mosquitoes in some areas soon began to display immunity against the spray. In the face of this situation the World Health Organization in the mid-1950s gave malaria control top priority in its programme and determined to marshal all available resources in an effort to eradicate the disease, and thus destroy the sources of infection, before the resistant strains of mosquitoes could take over.

Typhus, transmitted by body lice, had long been a scourge of armies and poverty-stricken populations suffering from the disruptions of war, and it recurred in epidemic proportions in many areas. During the first world war the toll taken by typhus, particularly in eastern Europe, was second only to that of the influenza epidemic of 1918, and the heavy incidence of typhus in Russia during the years of revolution and civil war provided a powerful incentive for the rapid development of public health measures. Immunizing serum was used to protect the troops of western Europe and America in the first world war and more thoroughly for all military personnel in the second, reducing the danger of the spread of typhus from the areas where it continued endemic. There were severe epidemics in German concentration camps during the war, however, and a form known as scrub typhus, prevalent in Asia and the South Pacific, took a considerable toll before special measures were used to check it. When DDT became available it greatly facilitated the elimination of the lice, or in the case of scrub typhus the mites, which transmit the disease. At the close of the second world war the United Nations Relief and Rehabilitation Agency (UNRRA) was able to forestall the anticipated typhus

epidemics by distributing quantities of DDT anti-louse powder to danger areas and administering it in the manner found effective in checking an incipient epidemic in Naples in 1943. In the following years prophylactic measures undertaken by the people's democracies of eastern Europe reduced the threat of new outbreaks in that area.

Other diseases carried by insects, both those such as dysentery or trachoma whose germs are merely transported by flies and those such as African sleeping sickness where the tsetse fly acts as host, yielded to a combined attack on the sources of infection, the means of access by the insect transmitter, and the insects themselves. The new insecticides supplemented the measures for public sanitation and personal hygiene which had already largely eliminated most of the insect-borne diseases from the technically advanced areas, and offered important new tools to reduce their prevalence in the regions where they remained widespread.

(*c*) *Water- and filth-borne diseases: typhoid, diarrhoea and enteritis.* At the opening of the century, typhoid fever was widespread and frequently fatal, even in the countries with relatively high standards of health and sanitation. The reduction of the incidence of this disease to an insignificant cause of death in northern Europe, North America and Australasia reflected the measures taken, city by city, to ensure a pure supply of water and milk and the proper disposal of sewage and refuse. These same measures played a major part in reducing the foremost cause of infant deaths, diarrhoea and enteritis, as well as offering protection against the reappearance of such water-borne pestilences as cholera. By the end of the first quarter of the century typhoid fever had been greatly reduced in most parts of these areas, and by the middle of the century, it had ceased to be a problem there, although it remained a serious disease in many parts of Latin America and eastern Europe, as well as in Asia and Africa.

In 1900 few cities could boast a pure, potable water supply or a safe supply of milk; by the middle of the century a pure water supply had become almost universal in cities and towns of the westernized areas, sanitary handling and pasteurization of milk were general, though by no means universal, and sewage disposal was fairly adequate. The change however did not come overnight. In the city of Chicago, for example, it required over seventy-five years to conquer typhoid fever. Steps to secure a pure water supply repeatedly proved inadequate to meet the conditions created by the growing population, pollution recurred, the incidence of typhoid jumped up, to be brought down again by new measures for control. Only when chlorination of water, and also pasteurization of milk, were finally made complete and thorough during the first world war was typhoid fever virtually eliminated from the city and its recurrence forestalled.

Other cities of Europe and America went through the same process at different times, some earlier and some later. Some had a readier source of pure water than others and a less difficult task of sewage disposal and were able to

achieve control more easily. Some outgrew their facilities and faced recurrent crises in their control systems.

As in the case of diseases carried by animal vectors, the control of the water-borne diseases was a cumulative process. With the reduction in the diseases, foci of infection disappeared and the danger of contamination was thereby reduced. In time the goal of a physical environment free from these major health threats was achieved throughout most of the industrially developed world.

Sanitary measures to break the cycle of infestation were also the means of controlling the major diseases produced by internal parasites. Of these the most widespread and debilitating were ancylostomiasis (hookworm), transmitted through the skin from soil infected by the deposit of faeces, and schistosomiasis (bilharzia), whose parasite also enters through the skin from water in which its host, a snail, is present. Campaigns to eradicate these debilitating infestations, most characteristic of rural areas, took the form of systematic detection and treatment, installation of latrines, wearing of shoes, and in the case of bilharzia chemical treatment of irrigation waters and streams to destroy the snail hosts. Such measures reduced the parasitic infestations to a minor problem in the developed countries, but these remained as major causes of debilitation in many less developed areas.

While quarantine, attacks on animal vectors and public sanitation produced the major safeguards against the scourges which threatened the total population, immunization also played a part against some of these diseases, namely yellow fever, typhus, typhoid and cholera, and it played a major role in combating some of the contagious diseases of childhood.

(*d*) *Contagious diseases of childhood.* With the aid of immunization, the developed countries brought under control those contagious diseases of childhood which constituted the principal killers of young children above the age of infancy and, next to diarrhoea and enteritis, took the largest infant toll. Combined measures to quarantine, immunize and treat these diseases reduced their incidence and limited their severity.

The basic techniques for the development of immunizing vaccines against bacterial diseases were at hand at the opening of the century in the ability to isolate the bacteria, to cultivate them in the laboratory—*in vitro*—and to experiment with the development of vaccines which would cause the body to generate antibodies, or of sera containing antibodies generated in the body of an animal which would give temporary, passive immunity when transferred to the patient. Following the development of the diphtheria antitoxin, safe vaccines providing a measure of immunity for varying periods were developed for such important diseases as typhoid, typhus, cholera, tetanus, whooping cough and tuberculosis. Large-scale inoculation of British, American and German troops against typhoid proved effective in the first world war; thereafter this and other preventive inoculations became general for military personnel, travellers and persons working in areas where such protection might be necessary.

Immunization of large parts of the child population against diphtheria virtually eliminated this major threat to the life of young children. Though the disease continued to be fatal in a large proportion of cases, its incidence was so reduced in the years after the first world war that some cities where hundreds of children had died annually from this cause at the opening of the century went for years without reporting a single death. Immunization against whooping cough was introduced later than that for diphtheria, but by the middle of the century it was part of the routine protection for infants and young children.

The virus diseases, however, presented more difficult problems although two of the first diseases against which immunization was used, smallpox and rabies, are virus diseases and vaccines were gradually developed for other virus diseases including yellow fever. The viruses causing such diseases as poliomyelitis, measles and the common cold for a long time could not be cultivated outside the living host as could bacteria. For more than forty years efforts to isolate the poliomyelitis virus and to develop an immunizing serum were unsuccessful, but in 1955 these efforts were finally crowned with success when vaccine produced by Dr Jonas Salk (1914–) showed substantial capacity to protect against this dread disease and offered the hope of bringing it under control.

By this time methods had been developed for cultivating viruses in the laboratory using certain animal tissues, such as eggs or organ extracts, and a basis was laid for the production of vaccine against other viruses as these might be identified. With the memory of the influenza pandemic of 1918 in mind, much effort was directed toward the identification of the viruses which produce the many types of influenza, and vaccines against several types were developed in the 1940s. When in 1957 a type of influenza started to spread from Asia around the world, the virus was identified and an immunizing serum was immediately developed, though not with sufficient speed and in sufficient volume to prevent an epidemic.

Some of the most stubborn and elusive of the viruses, those causing common colds, continued at the middle of the century to baffle widespread efforts to track them down. Until such time as each of the disease-causing viruses could be identified, isolated and grown in tissue cultures, control of virus diseases through immunization remained remote and the medical profession was forced instead to rely on the maintenance of general health through good nutrition, building up general resistance in the patient's body and controlling side-effects by means of the new drugs, most of which were ineffective against the viruses themselves.

Measles, scarlet fever and other childhood menaces no longer offered the same threat primarily for these reasons, as well as by reason of an apparent decline in virulence. At mid-century only an estimated one out of every thousand cases of measles in the British Isles and the United States proved fatal, whereas in Mexico and Egypt reports indicated that as many

as one out of every four or five cases of measles might still be ending in death.

(*e*) *Tuberculosis.* At the opening of the century tuberculosis was one of the chief causes of death in all western countries and was by far the principal killer of young adults. The tubercle bacillus had been identified by Robert Koch in 1882 and the manner of its transmission was understood. But no immunizing agent was known nor was the disease responsive to any known drug. The standard treatment was to transport the patient if possible to a climate thought to be more favourable to recovery; hence the location of sanatoriums in Switzerland and other mountain areas.

The attack on tuberculosis therefore had to take the form of organized efforts to prevent its spread by identifying cases before the infection was passed on to others, by modifying health habits so as to minimize the chance of either receiving or communicating the infection, and by building up resistance to the disease through improving the general level of nutrition and health. Such an attack necessarily involved more than the medical profession and public health officers, for it required the understanding and co-operation of the people themselves. The fight against tuberculosis thus became a major world-wide campaign of education and organization.

During the first half of the twentieth century the co-operative efforts of medical institutions, public health agencies and organized citizen groups drove down the death rate and the incidence of the disease in the industrially developed countries and finally began to bring a substantial reduction all over the world.

For treatment of the disease special sanatoriums were established which had the double advantage of isolating the patient to prevent contagion and of providing care. Systematic study of the disease by large numbers of specialists in many countries led to the conclusion that climate was less important than pure air and rest, to enable the body to build up strength to throw off the infection. Sanatoriums were therefore set up for local patients, bringing care within reach of those who could not afford to go to distant places, though the number of beds available was rarely sufficient. Even at local institutions, however, few patients could afford the cost of the long treatment generally required, and tuberculosis hospitals came to be widely supported by public health agencies and charitable bodies. The treatment itself was improved as methods were devised for collapsing a diseased lung to permit it to heal and as several types of chest surgery were perfected in the second quarter of the century.

The public health aspects of the disease were clearly recognized—as early as 1889 New York City had required doctors to report all cases of tuberculosis to the city health authorities—and most public health departments developed special programmes for tuberculosis control. One of the most important of such measures was the elimination of bovine tuberculosis as a source of infection to humans through pasteurization of milk and the eradi-

cation of infected cattle. The disease was virtually stamped out among cows in the United States and the Scandinavian countries, by slaughter of infected animals in the former country and segregation from breeding herds in the latter area, and elsewhere it was being continually reduced.

Effective tuberculosis control, however, required more than the isolation and treatment of cases which might come to the attention of doctors and health authorities, and the extension of public health measures. It depended upon the early detection of cases while treatment could still be effective and before the patient had had an opportunity to spread the disease to others. From the establishment of the first special tuberculosis dispensary, in Edinburgh in 1887, tuberculosis clinics undertook: to keep a close check on the recovered patient in order to detect signs of a new breakdown; to follow up the members of the family and others with whom the person had been in contact in order to detect those who might have contracted the disease; to seek to improve health practices and living conditions in the home in order to minimize the danger of contagion and to increase the resistance to disease of those exposed; and to conduct a general programme of education concerning the nature of tuberculosis and precautions to be taken against it.

X-ray photography made early diagnosis possible, and the tuberculin test of the skin gave an even earlier indication that the infection was present and might develop into the disease. In addition to the systematic follow-up of known contacts, mass chest X-ray surveys were undertaken in a number of cities and chest X-rays became standard procedure in routine physical examinations of food handlers, nurses, members of armed forces and other groups. Mass use of tuberculin tests on school children or on persons working in tuberculosis sanatoriums were used to identify persons in special need of watching. As the attack on tuberculosis succeeded in isolating and treating the more advanced cases, the emphasis shifted more and more to case-finding in the hope that early detection would both permit the disease to be arrested in the individual and prevent its spread.

At every stage in the anti-tuberculosis campaign a major role was played by citizen groups. Voluntary organizations to support the establishment of sanatoriums and arouse public concern were formed in the 1890s in Austria, Denmark and other European countries. In 1904 the National Association for the Study and Prevention of Tuberculosis in the United States focused the anti-tuberculosis movement on prevention and research, and this pattern was followed by citizen groups all over the world. Against no other disease was there so widespread a public campaign of health education and such broad and systematic financial support for study and treatment of the disease and rehabilitation of its victims.

From the 1920s on, and especially after the second world war, immunization began to play a part in tuberculosis control. A vaccine known as BCG developed at the Pasteur Institute in France became available in 1921, but its widespread use was delayed for some years, partly because an early batch of

impure vaccine was known to have occasioned a number of deaths. By the years after the second world war, however, prejudice against the vaccine had been generally overcome, BCG was being administered on a mass scale to children in a number of countries and the World Health Organization was sponsoring a programme for its use where the incidence of tuberculosis was still high. In the Scandinavian countries new-born infants were being regularly inoculated with the vaccine before mother and baby left the hospital.

In 1944 the long quest for a drug that would be effective against tuberculosis met with success in the discovery of streptomycin by Selman A. Waksman (1888–). Immediately a broad test of the drug's use, alone and in combination with other drugs, was set up under the co-ordination of the United States Public Health Service, and the basic conditions for its effectiveness were quickly established. In a very few years drug therapy had partially replaced the long and costly methods of treatment wherever supplies were made available. Many cases, especially those diagnosed early, could be treated at clinics without requiring hospitalization.

By all these means and as a result of general improvements in living conditions, nutrition, sanitation and health habits, deaths from tuberculosis in the industrial countries were steadily and substantially reduced, though the incidence of the disease rose temporarily in Europe during and after the second world war, reflecting the malnutrition and deprivations suffered by large segments of the population. At mid-century the advanced countries were looking to drug treatment, immunization, general health education and systematic techniques for detecting tuberculosis in the population as bases for an all-out effort to eliminate the foci of infection and to bring this ancient 'white plague' finally under definitive control.

(*f*) *Control of disease by drug therapy.* In the public mind the new 'wonder drugs' were the most dramatic of the twentieth-century developments in medical science. As preservers of lives threatened by major forms of infection their reputation was richly deserved.

The pharmacological research and experimentation which finally led to the development of the antibiotic drugs rested on the theory that chemicals could be found which for one or another reason would destroy specific micro-organisms without at the same time injuring the body. Advances in chemistry and in knowledge of the behaviour of bacteria in the last part of the nineteenth century had made the discovery of such chemicals appear probable. One or two such drugs had long been known, such as mercury for the treatment of syphilis and quinine for malaria. It was not however until 1910, when Paul Ehrlich discovered an arsenical substance for the treatment of syphilis known as salvarsan, that a systematic search for specific drugs was undertaken. Other arsenicals were tested against African sleeping sickness, since the germ of this disease was not unlike that of syphilis, and an effective compound, tryparsamide, was found in 1920.

With the exception of tryparsamide however, and of mepacrine found to be

useful against malaria, efforts to find drugs which would act as specifics against disease germs scored few successes. Most of the chemicals which would kill bacteria in cultures outside the body either killed the animal or lost their effectiveness when they were introduced into the body. The opinion grew in medical circles that chemotherapy was not likely to offer important new means for controlling disease.

In spite of these failures, however, a group of chemists in the laboratories of the German I.G. Farben dye industry persisted in the search and in 1932 found a compound which showed some effects against streptococcal infection in mice. In the following year the first of the sulpha drugs, prontosil, was tested clinically on humans and showed cures in cases of streptococcal septicaemia which would otherwise have been fatal.

In 1935 the developer of prontosil, Gerhard Domagk (1895-), published the results of his animal studies and the rest of the world woke up to the importance of this discovery. French scientists quickly established the fact that other sulphonamides produce similar results. By 1938 the effectiveness of the sulpha compounds against pneumonia had been detected in Britain and the drug had been synthesized in Britain, the United States and Russia. Within the next three years other sulpha compounds were developed, including sulphadiazine which was used in large quantities to combat infections during the second world war, and sulphaguanidine which effectively prevented dysentery during the war among fighting troops around the world. The battery of sulpha drugs thus brought a wholly new approach, that of specific drug therapy, to the control of various bacterial infections, including one of the major killers, pneumonia. They shifted the focus of medical thinking from general measures strengthening the body's resistance to precise remedies effective against specific disease agents.

Meantime, the discovery of the first of the antibiotics, penicillin, laid the basis for even more powerful weapons against specific diseases. Although for centuries the Chinese had used moulds to treat infected surface wounds, and anti-bacterial action by some moulds had been noted by Russian scientists in the 1880s and American research workers before the first world war, it was largely by accident that the British bacteriologist, Alexander Fleming (1881–1955), in 1929 stumbled on a mould which showed the ability to destroy certain types of bacteria. For a decade, however, this discovery remained of only academic interest. The identification of the sulpha drugs and their synthesis and rapid introduction seemed to point in a different direction. It was only on the eve of the war that two other British scientists, Howard W. Florey (1898–) and Ernst B. Chain (1906–), investigating penicillin along with other antibiotic substances, demonstrated that even in very minute quantities penicillin could inhibit the growth of the deadly staphylococcus bacteria. In 1941 the first human tests were carried on in England on cases of staphylococcus and streptococcus infections which had been given up as hopeless.

When the effectiveness of the drug against these infections was established

its tremendous importance for military use was immediately recognized, and the British scientists came to the United States to secure large-scale production. The supply was expanded rapidly. In 1942 the whole supply was sufficient to treat perhaps a hundred cases; by 1943 enough penicillin was being produced to provide all the armed forces of the United States and the western allies. For the next three years the military absorbed practically all that was produced and penicillin was not available to the civilian population, but when supplies were released immediately after the war it became the standard drug for the treatment of many types of infection all over the world.

Scientists, meantime, presuming that penicillin was only one of many similar substances which might have anti-bacterial effects, set out to discover other antibiotics, using a systematic method of inoculating soil, observing what antibiotics developed, and then testing their effects and determining their composition. Within the next dozen years some 200 antibiotic substances were identified which were effective against one or another type of bacteria, although only a few of the 200 proved to be practically useful. One of the most important was streptomycin, found to be potent against tuberculosis and other infections which were unaffected by penicillin. The first of the antibiotics to be produced synthetically, chloromycetin (chloramphenicol) identified in 1947, was especially potent against typhoid, typhus and other ricketsial infections. Aureomycin, identified in 1948, was the first of the 'broad-spectrum' antibiotics, found to be active against a wide range of bacteria and some of the large viruses.

The combination of the sulpha drugs and the antibiotics thus placed in the hands of the medical profession powerful tools which could directly combat a very wide range of specific infections and diseases. They made possible the survival of many of those wounded in war and could protect patients during and after difficult surgery. No longer was it necessary to depend largely on the body's own recuperative powers to fight off major infections; they could be attacked directly. Among the most spectacular results of the use of the new drugs were the reduction of venereal disease and of deaths from pneumonia.

The original specific against syphilis, salvarsan, brought only limited results as a means of controlling venereal disease, for it involved a long course of treatment, people were reluctant to seek treatment until the disease was well advanced, and the drug was ineffective against other types of veneral infection. The venereal diseases remained general and continually spreading in the population, with systematic control maintained only among military personnel and in ports

The discovery of penicillin changed the picture. Not only syphilis but other types of venereal infection could be treated by means of large single doses of penicillin or a short course of rapid treatment. This afforded a wholly new approach, provided the basis for mass campaigns and offered the hope that such diseases might eventually be eradicated.

Even more impressive from the point of view of mortality was the successful

treatment of pneumonia. In 1900 this was the leading cause of death in the United States. When the new sulpha drugs were found to be effective against the types of pneumonia which had been responsible for the high mortality rate, the death rate from this cause dropped until at mid-century it was only a fifth of what it had been fifty years before.

The use of the new drugs was limited, however, by the fact that in some patients they produced a bad and sometimes dangerous reaction. The use of antibiotics to suppress symptoms might mask underlying conditions and delay or prevent diagnosis and treatment of the disease. Moreover, new strains of bacteria or viruses constantly appeared which were resistant to some or all of the drugs; the development of immune strains of staphylococci in hospitals presented a new danger of hospital infections. Yet whatever their limitations and dangers, they brought a new era in the control of disease. It was the introduction of these new drugs after the second world war, together with immunization and the use of new chemicals to control animal vectors, which led to a reduction in death rates in the underdeveloped areas much more rapid than that which sanitation and the older forms of treatment had already brought to the industrially developed parts of the world.

3. *Reduction in infant and maternal mortality*

At the opening of the twentieth century infant death rates ranged from about one in ten in the countries with the lowest rates, such as Norway, Sweden and Australia, to about one in four in Russia and eastern Europe and one in three in much of Asia. By mid-century the rate in northern Europe, the USA, Australasia and the USSR had been brought down to less than one of every twenty babies born. In many areas of Asia, Africa and parts of Latin America where rates remained relatively high, they had dropped to the levels which had characterized many of the advanced industrial countries at the beginning of the century and were being rapidly brought in line with the new rates in the latter countries.

The sharp reduction in infant deaths reflected a combination of factors. The most direct point of attack was the improvement of conditions surrounding childbirth—hospital delivery under aseptic conditions, with medical attention available in case of complications, attendance of births by physicians, and training of midwives in antiseptic procedures for deliveries at home. The most important result of the hospitalization of births was to save the babies and mothers where complications were involved, and to avoid the danger of infection. By mid-century the age-old hazards of childbirth had been all but removed for mother and infant, especially after the anti-microbial drugs became available.

Of equal if not greater importance in reducing the death rate among infants were measures to protect the mother's health during pregnancy and to keep the baby healthy during its first year. At the opening of the century it was the rare mother who received medical care during pregnancy unless illness or

obvious complications developed. With the determined attack on infant mortality, however, it became apparent that the state of the mother's health was a vital factor in the normal birth and sound condition of the baby. The first of the pre-natal clinics was established in Paris in 1890 and some others followed in the same decade. The Scandinavian countries and Hungary were among the countries which pioneered in the setting up of systematic maternal and child health services, but it was only in the 1920s that such clinics became general in most countries. They were a central feature of the health programme of the Soviet Union. By the middle of the century pre-natal care was routine throughout the West, although a very considerable number of mothers still did not receive such care sufficiently early in the pregnancy to detect the signs of a disorder at the time when it could be most effectively remedied.

Maternal and child health centres which offered pre-natal care to mothers generally provided well-baby clinics and post-natal maternal care. Some infant hygiene clinics were the outgrowth of infant milk stations for poor or under-nourished babies; some originated as adjuncts to a maternity centre. Whatever their origin, clinics where babies were checked periodically and their mothers advised as to their care became a central feature of the public health services of most countries.

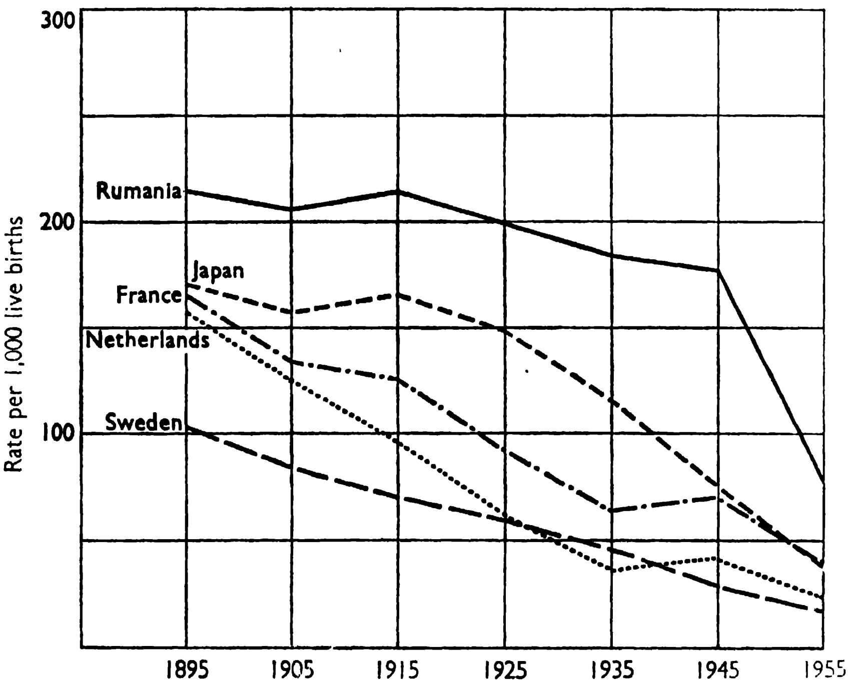

CHART XVIII. Trends in Infant Mortality Rates, 1900–55. Selected Countries. Rate per 1000 live Births.

Source: Woytinsky, *World Population and Production*, p. 167; *U.N. Statistical Yearbook*, 1960.

The advancing science of nutrition found its readiest application in the field of infant welfare. While adult food habits were often slow to change and to incorporate nutritional knowledge, far less resistance stood in the way of the scientific feeding of infants and of pregnant and nursing mothers. Wherever health services were extended and health education was widespread, infants in the families of rich and poor alike received the vitamins and other nutrients required to give them a good start in life.

General programmes of public health, sanitation and hygiene contributed perhaps as substantially to the reduction of infant mortality as did specific measures for maternal and child health. Infant deaths were also reduced, along with those of the rest of the population, by the control of communicable diseases and by the use of antibiotics against infections.

In the opening years of the century the principal causes of death among infants were diarrhoea and enteritis. In some countries these accounted for as much as a half of all deaths in childhood. In the United States they were the

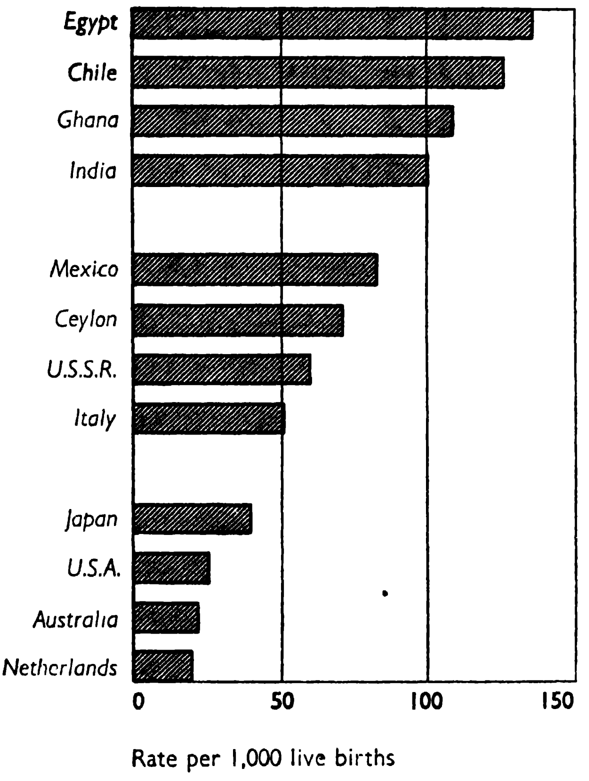

CHART XIX. Infant Mortality Rates, 1955. Selected Countries with High, Medium and Low Rates. Rate per 1,000 Live Births.

Source: *U.N. Demographic Yearbook*, 1960

third cause of death in the total population, exceeded only by pneumonia and tuberculosis. During the first half of the century this cause of infant deaths was almost eradicated in the advanced countries as a result of the general improvement in sanitation, specifically the protection of water and milk supplies. Sterilizing of milk used in bottle feeding and other care in the handling of infants' food supplemented public sanitation in protecting the infant population from these diseases. Growing health-consciousness was reflected in standards of personal hygiene and cleanliness in the home.

By the middle of the twentieth century deaths from diarrhoea and enteritis in the westernized areas amounted to less than 2 per cent of all deaths. The rate in the United States dropped from 143 deaths per 100,000 inhabitants at the opening of the century to 6 at the mid-century. In areas where general sanitation had not reached into many parts of the country, especially in hot climates, diarrhoea and enteritis remained the principal infant killers. In Egypt at mid-century for example, they were still responsible for a third of all deaths in the total population, and in parts of southern Europe, South America and Asia they continued to be responsible for large numbers of infant deaths.

Yet in spite of the great reduction in infant mortality a hard core of infant deaths remained. Deaths associated with prematurity, congenital conditions and other neonatal problems continued to challenge medical science and health practices.

The central feature of maternal and child health practices was that they were geared to maintaining health rather than simply to combating disease. At the opening of the century the expectation that many babies would die was part of a widespread fatalistic attitude. By mid-century this attitude had been almost completely reversed.

Infant and maternal care thus led the way in the shift of emphasis which characterized general health programmes in these years from care to prevention, and then to the positive enhancement of health. In line with this approach, school health services were introduced or extended in most countries to provide for periodic health examinations of all school children in order to detect and correct physical defects. Health teaching was introduced into the schools; campaigns were conducted to promote personal hygiene, immunization of children, and check-ups to detect such diseases as tuberculosis or syphilis.

The Red Cross in many countries offered courses in first-aid and home nursing. Public health nursing services were established or expanded with the double purpose of making nursing services available and of providing a channel for health education; such nurses were sometimes aptly named 'instructive visiting nurses'. In France, where a system of family allowances was established, those who administered the programme were trained as nurses as well as social workers and had the duty of carrying health education to the families they served. In Germany public health nurses visited the homes following the birth of each child. Health education and measures to promote

good health became increasingly important aspects of public health programmes.

4. *Chronic and degenerative diseases*

The control of major communicable diseases and prevention of infant mortality left chronic and degenerative diseases, most especially heart and other circulatory diseases and cancer, as the principal causes of death. The lengthened span of life, following success in preserving the health of the young, brought the health problems of older people to the centre of the stage.

In the industrially advanced countries death rates from heart disease and cancer continued to mount absolutely as well as relatively, in the face of concerted efforts to trace their cause and of constantly improved techniques for diagnosis and treatment. It was an open question how far these diseases were produced or aggravated by the conditions of modern life—strain and anxiety, diet, atmospheric pollution, smoking—how far their incidence merely reflected the survival of persons who would formerly have succumbed to one of the traditional killers before these degenerative diseases had a chance to develop, and how far better methods of detection were bringing to light cases which would not have been recognized in the past. Whatever the source, their presence was very real and the further improvement in health and survival in the developed countries depended upon progress in their control. It was indicative of the role which these diseases had come to play in the advanced countries that in 1955 the World Health Organization inaugurated its first attempt to focus international co-operation on chronic disease by establishing a study group in the European region on the chronic degenerative diseases of the cardiovascular system. The WHO expected this inquiry to point the way to international co-operation on other important chronic diseases such as rheumatic conditions and cancer.

Chronic and degenerative diseases did not appear generally to arise, like communicable diseases, from the invasion of a micro-organism whose entrance could be prevented or which could be directly attacked by an immunizing agent or antibiotic drug. They appeared to reflect conditions of imbalance or malfunctioning arising within the body itself, and had therefore to be treated or forestalled by approaches which might involve the entire organism.

The attack on these still unconquered ills therefore required an immensely complex marshalling of medical knowledge and skills. It led to efforts: to recognize hereditary predispositions to certain forms of breakdown; to understand physiological processes as they involve the functioning and interrelation of all parts of the body; to identify the internal secretions of endocrine glands and extract or synthesize the hormones which they produce in order to be able to restore balance; and to understand the chemistry and behaviour of living cells and the effects of nutritional factors, physical stimuli and radiation.

Much progress in the understanding and control of diseases which reflected

a chemical imbalance in the body was achieved during the second quarter of the century through advances in knowledge and use of hormones.

The need to understand the mechanisms which maintain in the body a constant internal environment and a chemical balance had been well recognized before the close of the nineteenth century. Physiologists were then studying the process of metabolism in relation to nutrition and the functioning of the central and sympathetic nervous systems as regulators. A number of scientists, especially in Switzerland where cretinism and goitre arising from thyroid deficiency were prevalent, were beginning to study the internal secretions by which certain glands supply the body with regulatory substances. During the first quarter of the twentieth century the principal glands of internal secretion were studied, some of the hormones which they secrete were identified, and their major functions were detected.

The first of the hormones to be identified, adrenalin, was isolated in 1901 and was synthesized and used in treatment before the first world war. Other hormones were isolated during this period, but it was not until the 1920s that insulin was extracted in a form that permitted its use to enable persons suffering from diabetes to function normally. A succession of hormones were identified, extracted and synthesized in the following decades and provided a means of influencing chemical balance and adjustment and an approach to the treatment of some of the chronic and degenerative diseases.

Once the hormones had been extracted and could be administered in differing volume, it became possible to observe their effects. Every general advance in physiology provided a fuller understanding of the processes to which the hormones contributed. Yet by mid-century an area of uncertainty still surrounded what was then known about most of the endocrine glands and their operation and, although hormones were being extensively used in medical practice for therapeutic purposes, their known or potential side-effects could present serious problems.

In spite of these limitations, however, advances in this branch of medical science were among the most important developments of the period and their significance was expected to increase markedly in the future. Their principal medical value was in relation to the chronic and degenerative diseases which arose from some disorder in the inner environment and normal functioning of the body. With an ageing population, checking the processes of degeneration through control of the mechanisms for normal balance offered the principal possibility for a further lengthening of the life span and, perhaps more importantly, for maintaining health and vigour through the later years. The hormones cortisone and ACTH discovered in 1949, for example, relieved the crippling and pain from one of the most prevalent of the degenerative conditions, rheumatoid arthritis.

Results achieved by horticulturalists during these years in the use of plant hormones, moreover, pointed to a wide potential in the human field. The successful use of plant hormones to modify, accelerate, enlarge and distort

growth, to change the time of flowering, to induce a tree to hold or drop its leaves or fruit, revealed these substances as tools for the manipulation of living organisms. The use of sex hormones to affect human fertility and sterility and to alter secondary sex characteristics pointed in the same direction. This branch of medical science appeared to be placing in the hands of the medical profession instruments which might not only preserve and prolong but alter the character of life.

Yet although hormones played a role in the treatment of chronic diseases somewhat parallel to that played by the antibiotics in the treatment of infections, their use was less simple and direct, for instead of attacking a specific micro-organism they were called upon to affect the extremely delicate and complex interrelationships essential to the functioning of the total organism and its several organs. With the notable exception of insulin, whose use to control diabetes became well established and routine, and in some cases the use of sex hormones, most of the hormones were still being used tentatively and experimentally at mid-century for the treatment of functional disorders and the maintenance of health in maturity and old age.

Early detection coupled with treatment by surgery and radiotherapy remained the weapons available against cancer. In the effort to determine the factors producing malignancy and to discover some substance which might attack the diseased cells without destroying healthy tissue, research was pursued along many different lines, including the carcinogenic effects of chemical substances, radiation, physical damage and hormone action, the possibility of virus origins, the role of genetic factors. In view of the success achieved by medical science in other fields there was general hope that means to control cancer would also be found, and research was pressed forward with a sense of urgency on the chance of saving the lives immediately threatened. It appeared that success in this quest, and in relation to other forms of degeneration and malfunctioning, would depend in the final analysis on progress in understanding the life process itself.

Conditions causing debilitation or discomfort, as well as those leading to premature death, were the objects of intensive study and extensive treatment. Deficiency diseases and malnutrition were attacked by means of improved knowledge of nutrition and the identification and use of vitamins.* Recognition of the nature of allergic reactions in the first decades of the century laid a basis for relief of the discomfort suffered by large numbers of people, estimated at perhaps 3–5 per cent of the population, with allergies to certain substances. Such symptoms as asthma, hay fever and skin eruptions were brought under control by methods for identifying the offending substances, desensitizing the individual to them and, with the discovery of antihistamine drugs after 1945, by directly counteracting the allergic reaction.

One of the chronic conditions found to be most widespread in mass health surveys or the examination of draftees for military service was dental caries.

* See Chapter XIV, section on Nutrition.

Although dentistry was one of the oldest of professions and methods for treating dental decay and filling dental cavities were well developed by the opening of the century, the services of dentists were available to only a very limited segment of most populations.

In the early twentieth century emphasis began to be placed on the prevention of tooth decay, and the toothbrush became almost a symbol of advancing civilization. Following a demonstration programme to provide dental services for school children in an American city (Bridgeport, Connecticut, 1914–24), in which dental assistants were used to clean teeth and teach oral hygiene, dental hygiene became an auxiliary profession, dental hygienists received special training and people were encouraged to have their teeth cleaned professionally at regular intervals. Experiments with chemical treatment of children's teeth to protect them against decay brought substantial results and led to the addition of fluoride to public water supplies, although popular fear that fluoridation might be otherwise harmful delayed the adoption of this preventive measure in some places.

Dental clinics began to be extensively established, especially for school children, in the 1920s and 1930s. Buenos Aires, Argentina, in 1934 was one of the pioneer cities to set up municipal dental clinics providing all types of dental services to those unable to pay, and dental services free of charge were extended to the entire British population by the National Health Act in 1948. Dental care, however, remained one of the health areas in which provision of services and preventive measures were most unevenly developed.

5. *Conditions requiring surgery*

During the last quarter of the nineteenth century techniques of modern surgery had been established in the practice of asepsis and the effective use of anaesthetics. Spectacular new developments in surgery came less from improvement in the basic techniques to prevent infection and in the dexterity of the surgeon than from a greatly increased knowledge of the physiology of the body, the availability of new diagnostic instruments, the use of new types of anaesthetics and the use of antibiotics to prevent post-operative complications.

New knowledge of the chemistry and composition of the blood played a central part, for it made blood transfusion possible. Although the transfusion of blood had been practised occasionally for several hundred years, it did not constitute part of the technique of surgery at the end of the nineteenth century, primarily because of two factors: the disastrous consequences which had often followed the introduction of the blood of another individual and the difficulty of preventing the blood of the donor from coagulating before it was introduced into the circulatory system of the recipient.

During the first decade of the twentieth century the problem of coagulation was satisfactorily solved and the existence of blood types that are incompatible with each other was discovered by Karl Landsteiner (1868–1943). Once it was recognized that only blood of the same or of a related type may safely be trans-

fused and the major blood types were known, transfusion became a safe and useful means of counteracting surgical shock and compensating for loss of blood in the surgical process. Transfusion techniques were sufficiently developed by the time of the first world war to be introduced into military surgery, especially in the medical services of the American armed forces where they were most extensively used.

In the following years blood transfusion became standard procedure in relation to many surgical operations, and improved methods of preserving whole blood were developed. Hospitals, the Red Cross, communities and the armed services maintained blood banks from voluntary donors in order to have blood of all types available instantly in case of emergency.

In the early years of the second world war a technique was developed for extracting the plasma from the blood, thus securing a product which did not deteriorate as did whole blood and which could be used indiscriminately since it did not contain the properties which differentiate the several blood types. While whole blood was more effective than plasma for some purposes, the use of plasma during the second world war was a major factor in reducing mortality from wounds. In the following decade efforts to find blood substitutes which could be synthesized and would not depend upon blood donations were pursued with some success, and substances were developed which could be used in place of blood in some cases.

The development of new anaesthetics and their careful use in relation to the physiology of the individual patient was the basis of some of the advances in surgery. Ether, which had been used as the principal anaesthetic since the nineteenth century, was supplemented or superseded by a variety of substances which produced different conditions of narcosis and which could be administered locally or by injection into the blood stream or spinal canal rather than through the respiratory system. These new anaesthetics, and new methods of administration, made new types of operations possible such as those in the thoracic cavity or upon the heart, and they could be used on patients whose system might not stand anaesthetics of the older type. The administration of anaesthetics adjusted to the patient's physiology and to the surgical procedure to be followed became a highly specialized field, so much so that a special diploma or degree for anaesthetists was established in 1935 in Great Britain and in 1936 in the United States.

In addition to depending on blood transfusion and carefully adjusted anaesthetics, the modern surgeon made use of the expanding knowledge of human physiology in a myriad of other ways. Much surgery came to have a physiological objective, to eliminate functional disturbances and not merely to correct an anatomical deformity or remove a diseased part. By severely lowering the temperature of the patient's body, physiological processes were slowed down to permit operations which would have been highly dangerous had these processes continued at their normal rate. Equipped with increased understanding of the functions performed by each part of each organ, surgeons learned how

to keep the patient functioning by supporting the physiological activities of the body, such as normal blood pressure and fluid balance. Especially in difficult operations in the abdominal cavity, they used sulpha drugs and antibiotics to reduce internal sources of possible infection, for protection during the operation and to control post-operative complications. The new knowledge of nutrition enabled them to feed patients intravenously when they could not take nourishment in the normal manner, though the problem of reducing the necessary nutrients to a form in which they could be received directly into the blood stream presented continuing difficulties. Extended knowledge of the brain and nervous system provided a basis for the development of brain and nerve surgery, including the surgical treatment of such diseases as hypertension by operation on the sympathetic nervous system in order to relax the blood vessels. In all these delicate operations highly sensitive measuring and recording devices kept the surgeon informed as to the detailed condition of the patient throughout the operation.

During the second world war elaborate and highly refined surgical techniques were developed to rehabilitate the seriously injured. In conjunction with skilfully designed prosthetic devices, muscles which remained were often substituted for those which were gone and were taught to perform new functions. A large proportion of the people handicapped by war injury were thus enabled to function at a level undreamed of for persons who had suffered similar disabilities in the past. In the years after the war these techniques were applied to the rehabilitation of persons similarly injured on the roads or in other accidents of civilian life. Modern surgery and medical science made the helpless cripple a rare figure by the middle of the twentieth century, in spite of the many victims of war and of motor traffic.

6. *Hazards created by industrial society*

Developments in respect to life and health were not wholly one-sided during these years, however, for modern society brought with it new hazards of its own. Apart from the loss of life through vastly more destructive warfare than prior ages had imagined, and apart from the possible, but unverified, effect of the pace of modern living in increasing the incidence of some chronic diseases such as hypertension and heart conditions, many aspects of modern living produced dangers to life and health. Accidents were fourth in the causes of death in the United States at mid-century as compared with eighth fifty years before; a third of the accidental deaths were on the roads and approximately a fifth in industry. The toll of traffic deaths and injuries mounted everywhere as the number and speed of motor vehicles increased, in spite of regulations, safety education and improvements in the design of roads and vehicles.

Industrial hazards were gradually reduced through improvements in the design of industrial plants, more rigorous standards for factory inspection, and legal and economic pressures on employers to safeguard their workers' health and safety. New industrial processes, however, constantly added new menaces

to those long familiar, especially those involving the use of radioactive substances, new chemical industries and other new substances. The International Labour Office, reviewing the range of industrial hazards in 1955, listed in its bulletin on *Occupational Health and Safety* hazards from chemical and other substances in a long list of industries, including mining and refining, the manufacture of insecticides, the manufacture and use of colours and paints, textile printing, the preservation of hides and wood, and the glass, rubber and pharmaceutical industries.

In some localities smoke, fumes and gases from industrial operations and motor traffic combined with atmospheric conditions to present serious health hazards. Occasional disasters dramatized this threat and some cities, such as Los Angeles, USA, learned to live with recurrent smog resulting from an atmospheric condition known as 'inversion' in which the fumes which are normally dissipated are trapped and blanket the area. The problem was of sufficient international importance to lead the World Health Organization to call a regional European conference on the subject of air pollution in 1957.

The coming of atomic fission brought a new and most serious threat to health in the form of radioactivity. Even before atomic power generators were placed in operation, the International Labour Office, the WHO and national health agencies were at work on means to protect workers in the multitude of plants where radioactive isotopes were being used, and in the transport of radioactive substances. The disposal of radioactive waste from atomic installations and the dangers of an accidental release of radioactive material presented grave problems to communities near such installations. The exact extent of the menace created by the testing of nuclear weapons was hotly debated during the 1950s, but the fact that all life had already been in some degree affected was acknowledged by all, and no official reassurances could conceal the fact that mankind was as yet without protection against this overwhelming danger.

As evidence of this new development in the field of health, the WHO in 1955 sponsored the first international training course for 'health physicists', a new category of professional workers made necessary by the health problems involved in reactors, radiochemical laboratories and the factories and laboratories using radioactive materials.

7. *Mental illness*

At the middle of the twentieth century two out of every five hospital beds in Europe and North America were occupied by mentally ill patients. It was estimated that one in every ten persons in the population of these countries would suffer in the course of his life from some mental disorder.

It was not possible to determine how far the vastly increased number of persons receiving treatment for mental illness reflected improved diagnosis, the mere fact that additional hospital facilities were available, increased numbers of old people in the population suffering from various forms of senility,

the conditions of modern living which made it less feasible to leave some cases at large, or a tendency of more people to break down under the strains and anxieties of modern life. Certainly mental illness was much more widely recognized than it had been at an earlier time, though it was doubtful that its actual incidence was appreciably, if any, greater than in the days when the severely disturbed were thought to be 'crazy' or 'possessed' and the mildly ill were simply regarded as 'queer'. In any event general recognition of mental and emotional disorder as a form of illness was one of the outstanding twentieth-century developments in the field of health, and with the conquest of so many of the physical diseases the relative importance of mental illness increased.

Medical advances in the treatment of mental illness followed two major lines: techniques for bringing the psychotic patient back into contact with reality, and techniques for psychotherapy, including psychoanalysis based on a growing understanding of the processes of mental and emotional growth and adjustment. In addition, research into the possible physical and biochemical basis for mental and emotional disorders brought clues as to conditions which might be treated at the physical level.

On the organic side one form of mental illness, general paresis, was successfully traced to syphilis, and some other conditions appeared to be related to extreme malnutrition. Other efforts to link mental illness with focal infections, exposure to certain physiological stimuli, brain toxicity or type of body structure were less successful, but at mid-century the search for organic factors was being continued vigorously, especially by biochemists and neurologists. Frontal lobotomy brain surgery was introduced in the 1940s but observations as to the effect of the operation on the patient's personality led to a decline in popularity after a period in which it was in vogue. Various forms of chemotherapy were also attempted, some related to one or another of the physiological hypotheses that had been advanced.

Psychotherapy depended upon the ability of the therapist to establish contact with the patient, and various methods were developed to break through the patient's wall of unreality. These consisted chiefly in subjecting the patient to some form of severe shock, using insulin or electric current. In the mid-1950s new types of drugs known as tranquillizers began to replace shock as a means of quieting the patient's disturbance and allowing the physician to reach his consciousness. The patient's recovery, however, depended not upon shock or drug treatment but upon his psychological restoration, either with the direct psychotherapeutic assistance of the physician or by his own capacity for recuperation once the disturbing elements were held in check.

Prolonged psychoanalysis was extensively used to treat mild psychoneurosis and to some extent for intensive treatment of psychotic cases. More limited psychotherapy, based on psychoanalytic concepts, was included in most treatment of both psychoneurotic and psychotic patients. Group psychotherapy was coming to be used increasingly as the value of group experience for some

patients came to be understood and the shortage of personnel made group treatment desirable.

Yet in spite of much effort and the return to normal living of a growing proportion of mental patients, medical science had a long way to go before it would be able to claim mastery in this field.

Much of the progress in dealing with mental health took the form of early diagnosis and psychotherapeutic treatment before mental disturbance should become far advanced. Child guidance clinics treated emotionally disturbed children. Mental illness occasioned by syphilis was brought under control as the incidence of that disease was reduced. Some types of breakdown, most notably alcoholism, were recognized as forms of mental illness and were made the object of special physical and psychotherapeutic treatment. Alcoholics were treated medically with the aid of a drug, disulphiram, which made the patient's body unable to tolerate alcohol; improved diagnostic techniques enabled the physician to distinguish the level and type of alcoholism and to provide the kind of psychotherapy most likely to be effective before the disease had produced a condition of apparently irreversible deterioration.

In all aspects of medicine the interrelation of psychic and bodily factors received increased attention. Psychosomatic medicine was far from new; it was in fact the basis of much of the traditional 'healing art' in all societies. But as a scientific concept, consciously and systematically applied to the understanding and treatment of specific conditions of ill health, it came to occupy a more and more important place in the second quarter of the twentieth century. Psychosomatic factors were presumed to be more involved in the chronic diseases such as hypertension than in those produced by infections, and their growing place in medical study and practice accompanied the rise in importance of these diseases.

In even broader perspective, psychosomatic medicine was only one aspect of the growing tendency to treat the patient as a whole rather than to treat only the disease. During the long struggle in the nineteenth and early twentieth centuries to conquer one specific threat after another, medical science and medical practice had sometimes tended to lose their traditional focus on the patient and to become disease-centred. But as the nature of the health problems changed and the emphasis shifted to the maintenance of positive health, the patient as a person again became the object of attention. With greater understanding of physiological processes and the chemistry of living cells, medical science tended to seek the basis of much pathology in general rather than specific causes and to provide treatment in terms of the body as a whole rather than a specific disease. In addition the social elements in the individual's life situation, which public health reformers had long stressed, received renewed attention as essential factors in health, and professional workers trained to analyse these factors and help patients to cope with them were increasingly included as parts of medical teams.

By mid-century medical science had thus moved into the wide field of the

individual in relation to himself and his society, as it approached its new task of furthering the positive health of those whom it had saved from the killers of the past.

III. PROVISION OF MEDICAL CARE

1. *Development of the medical professions*

At the opening of the century medical education in all western countries combined both academic teaching to convey theoretical knowledge and hospital training to provide practical experience. British and continental European systems differed somewhat in their balance between theory and practice, as a number of British medical schools were directly attached to hospitals where there was more emphasis on training through bedside practice, while elsewhere medical faculties in universities placed somewhat greater emphasis on theoretical knowledge. Research in the basic sciences related to medicine was carried on by faculties of science or medicine or in special research institutes, while clinical and pathological research was generally a hospital activity. Latin American countries, Japan, Turkey and other areas which followed the lead of one or another European country tended to stress the academic aspect of training, while the British dominions, India, and other areas under British influence reflected the closer association of medical training with hospital practice found in Britain.

By 1900 second-class medical practitioners with substandard training had been largely eliminated in Europe, except Russia, but they continued in the United States where medical schools were insufficiently regulated and, in addition, a number of medical sects claimed to practise distinct types of medicine and maintained training institutions for their followers. Partly in response to public pressure, the medical profession in that country undertook drastic reforms in the decade 1910–20, eliminated substandard schools which lacked university affiliation and often a hospital base as well, and did away with second-class practitioners. In the resulting system medical schools were attached to universities, much of the training was provided through clinical experience in hospitals associated with universities as teaching hospitals, and clinical research was stimulated by the close relation between university and hospital.

Public health, which was an integral part of the German and British systems of training, was at first less generally included in the United States until after the first world war, when schools of public health were established at two leading universities; thereafter it received special emphasis in American training. In the USSR and the people's democracies of eastern Europe medical education, which had developed from a strong base of traditional European training, became largely oriented toward public health in line with the role of the physician in the health programmes of the socialist states, and the USSR after 1940 established special schools for organizing public health services.

By the second world war, the American system of medical education was at least on a par with the European, and after the war large numbers of persons from countries where training had been interrupted, facilities destroyed and scientific communication cut off by war, looked to the United States to help bring them up to date on medical progress. As a result of this interchange, features of training which had become part of the American system were introduced elsewhere.

As medical knowledge expanded and medical practice became more refined, both training and practice became highly specialized. In surgery alone as many as ten distinct specialities came to be recognized as the basis for special training, certification and professional organization. The resulting tendency was for an increasing proportion of medical practice to be carried on in hospitals where technical equipment and nursing services were available to facilitate and support the physician's work and for the disparity in available medical services to increase between those localities or groups in the population which had access to specialized services and those who must rely on the less intensive training and experience of the general practitioner.

For dentistry, regarded by some as a specialized form of medical practice and by others as an independent area of knowledge and professional skill, courses of training were developed, including clinical practice, comparable to those for medical practice. As the close relation between general health and dental health was recognized, training and practice in dentistry came to rest on a broader basis of general medical knowledge. In most places the supply of dentists remained far short of that needed to provide dental care according to modern standards.

All medical training was long and costly; that of the specialist was even more so. In nearly all countries, not alone those of meagre resources, provision of sufficient training facilities and the financing of the training for a sufficient number of doctors to serve the population became a critical problem. Responsibility for meeting the problem was generally assumed by governments, which provided subsidies to medical schools and stipends to medical students. In a number of countries students receiving government aid for their medical studies were required to practise in a rural area for the first two years after leaving school, a device adopted in an effort to overcome the disparity in medical service available to rural and urban residents.

The medical professions were strongly organized into national associations and into associations of specialists which originated in the last half of the nineteenth century and increased in number as new specialities developed. In co-operation with other national bodies such as hospital councils, they set professional standards and criteria for medical ethics. The organized profession played an especially large role in the licensing of practitioners in the English-speaking countries. In continental Europe and elsewhere standards for licensing were usually set by governments rather than by the organized profession. Where national professional bodies were powerful they tended to exert

a conservative influence on the manner in which medical services were supplied.

The members of the medical profession functioned increasingly in teams with members of other professions, and depended on the work of nurses and laboratory technicians, on the availability of facilities for the care of patients in well-equipped hospitals and clinics, and on the preparation and dispensing of drugs by reliable pharmacists.

Nursing as a profession followed the pattern established by Florence Nightingale (1820–1910) who in the years after the Crimean war secured the establishment by hospitals of schools to train nursing instructors and visiting nurses to care for the sick poor. Because of the value to hospitals of the nursing service provided by students in training, however, schools tended to concentrate on the hospital rather than the public health aspects of their programme in Britain, the United States, the Commonwealth countries and the parts of Europe to which the 'Nightingale' movement spread.

The nursing profession organized itself in each country and was one of the first of the health professions to form an international body, the International Council of Nurses, established in 1899. A major purpose of the organization was to secure the passage of legislation regulating the practice of nursing, standardizing the nursing diploma, and requiring the diploma in order for a nurse to be 'registered'. The first such act was secured by the organized nurses of New Zealand in 1901.

Nursing schools were originally wholly connected with hospitals but gradually the nursing profession began to seek a university base, first for the training of teachers of nursing and then in the 1920s and 1930s to train nurses in broad fields of public health, for administrative responsibilities and for specialized services. At mid-century nursing retained its hospital base but much of the responsibility for public health programmes fell on nurses, who engaged in health education and often provided the full-time staff for services to which doctors acted mainly as consultants.

As nursing developed and spread, it played a special role in the changing position of women for it was one of the principal fields of employment entered by women at the point where they were beginning to seek work outside the home. The profession served this function for middle-class European women in its initial phase during the latter part of the nineteenth century, and again for the women of the developing countries in the course of the twentieth century.

In time of war or disaster and in the face of the great expansion of health services, trained nurses were repeatedly or constantly in short supply. Although the ratio of graduate nurses to the population was 217 per 100,000 in the United States in 1950 as compared with 16 per 100,000 in 1900, there was so great a shortage in 1950 that hospitals were understaffed and public health posts were unfilled. To meet this situation the Red Cross in many countries developed training courses for volunteer nurse's aides and organized their

use, both to supplement regular nursing services and as nurse reserves for time of disaster.

The elaborate diagnostic and treatment techniques made possible by much of the new medical knowledge required a variety of technicians skilled in performing other specialized supporting services such as laboratory analysis and X-ray operation. The development of training, the establishment of standards and the organization of these sub-professional fields assured the physician or surgeon of performance on which he could rely. The compounding of drugs became a specialized function carried on by licensed pharmacists, druggists, chemists or apothecaries.

Much of the manufacture of drugs was taken over by large pharmaceutical firms, which not only produced pharmaceuticals in enormous quantities but carried on basic research, often in collaboration with medical schools and hospitals. In order to identify and standardize the great number of medical preparations and thus both to enable the physician to be sure of what he was prescribing and to protect the public from fraud, national governments adopted official pharmacopoeias in which drugs were specifically defined in terms of their ingredients and strength. By the mid-twentieth century, more than 30 countries had compiled a national pharmacopoeia, while other countries had adopted as official the one prepared by some other country.

In order to facilitate the international sale of drugs, and to serve the convenience of persons travelling from one area to another, steps began to be taken at the opening of the century to establish uniform standards internationally. Following the first international conference on the subject sponsored by the Belgian government in 1902, the Brussels agreement of 1906 proposed uniform nomenclature and standards of strength for many important drugs. The League of Nations set up a technical committee to draw up an international pharmacopoeia, and this work was completed by the World Health Organization, which published the International Pharmacopoeias in 1951 as a guide to encourage national governments to adopt uniform terms and standards.

2. *Cost of medical care*

As a result of the great advances in medical science, provision of medical care became an increasingly costly process. Elaborate diagnostic techniques through laboratory examinations, X-ray, and such devices as the electrocardiogram or the electroencephalogram could not be maintained by the individual physician but had to be supplied on a wider basis through hospitals, specialized diagnostic services or group medical practice. Treatment often involved expensive drugs, expensive surgery and expensive specialized care. The need to meet the cost of such services presented an acute problem in all countries; in some it was a cause for serious controversy.

Traditionally medical care had been received and paid for by those who could afford it, while the indigent sick had been cared for in publicly main-

tained almshouses or by religious orders or by private charity. In a few places, notably in Sweden and Norway, hospitals had been maintained as public institutions from their start in the early nineteenth century, and some medical care was offered by physicians on the public payroll. The more usual pattern, however, was that of the private physician and the privately endowed and operated hospital, except for such special types of institutions as mental hospitals, leper asylums and sometimes tuberculosis sanatoriums which were more generally maintained as public facilities. The private physician lived from fees paid for his services in the same manner as the lawyer, and his patients were those who could pay, except as he chose to treat poor patients without charge or for a nominal fee. Hospital services were paid for by the well-to-do, and those unable to pay were treated as charity patients.

This uneven system of care and payment was modified by the introduction of health insurance. Beginning with the German social insurance system of the 1880s, the insurance principle was widely adopted to spread the cost of medical care, chiefly for industrial workers whose earnings could be taxed to provide a fund out of which medical bills of all workers covered by insurance would be met. Health insurance became part of the social insurance system of nearly all industrial countries during the first half of the twentieth century, with the conspicuous exception of the United States where the organized medical profession resolutely fought its introduction on a broad scale and health insurance schemes remained voluntary or limited to particular groups.

Medical benefits were also generally included among the perquisites of various forms of employment, as for members of the armed services and their families, war veterans, the staffs of educational and other institutions, members of labour unions whose contracts called for health funds to be maintained by employers, certain classes of public employees. All these piecemeal methods, however, left medical care unevenly distributed, especially in case of major illness, and the burden of its cost fell heavily upon those not eligible for free service or not adequately covered by some form of insurance or other arrangement.

In the face of this situation many countries shifted a larger and larger proportion of the costs of medical care to the public treasury. State contributions to social insurance plans were increased to make broader coverage possible.

By the second quarter of the century the tendency was toward direct medical services supported by public funds and provided to certain categories of the population without charge. Public hospitals, clinics and medical consultation, available as a public service and not as an act of charity, offered a widening range of service not only to the poor but to the general public.

Some of the impetus for this trend came from the public health movement, for it became increasingly clear that it was impossible to maintain an effective programme of disease prevention unless treatment were also included. Public health programmes came to include aggressive measures to detect the presence of unrecognized or untreated disease in order to ensure early diagnosis and

treatment and the elimination of foci of infection. Mass procedures were developed and campaigns launched to locate cases of tuberculosis, venereal disease, diabetes and cancer in whole populations, and statistical methods were designed for estimating the probable extent of various diseases on the basis of sample surveys. Standardized procedures for detection were developed—such as tuberculin and other tests for tuberculosis infection and periodic mass chest X-ray surveys, tests of urine sugar for diabetes, the Wassermann blood test for syphilis. Mass education campaigns taught people to recognize possible symptoms of cancer and to seek immediate diagnosis.

But unless it were possible to follow through with treatment when a programme of case-finding had been carried out or unless a programme for future prevention could follow treatment for a recurrable ailment, the broad objective of public health would not be served. Public health programmes thus expanded to incorporate treatment services along many lines.

Countries differed markedly in the extent to which they made the direct provision of medical care an integral part of their public health programmes. Differences reflected not only differences in economic resources and in institutional arrangements, but in judgment as to how to use medical resources effectively. Opponents of systems of prepaid or free medical service thought that it was necessary to retain the barrier of direct and immediate cost to the patient to prevent excessive and wasteful demands for medical service for minor causes by persons with hypochondriac tendencies. Supporters of the view that medical services should be fully available stressed the importance of early diagnosis and treatment and wished to encourage medical consultation at the appearance of first symptoms.

With the emphasis upon positive health, the European countries in the 1950s were beginning to explore the advantage of a family health consultant, to keep in touch with the family continuously, not merely for the treatment of illness which might develop but to promote the health of all the members of the family group. This was one of the newer developments to which the WHO through its regional organization lent support.

3. *National programmes of health services*

When the United Nations reviewed the development of health services around the world in the decade following the second world war it noted not only that such services had been extended to segments of the population not previously covered but that an increasing number of countries were adopting comprehensive health schemes. In such schemes preventive, curative and educational aspects were integrated into a single system of services provided directly by the government.

Great Britain went the whole way in shifting the financing of its health services from social insurance to tax support and in undertaking to provide comprehensive services to all on a national basis. The pattern for the British National Health Service was set by the experience during the second world

war in making use of all available professional and hospital services under an integrated emergency medical service to care for civilian and military wounded and sick. The wartime measures systematized first-aid, out-patient and hospital services and distributed them so as to make them universally available.

The National Health Service, enacted in 1946 and put into effect in 1948, replaced a system in operation since 1911 under which insured workers, but not their families, were entitled to medical care. Under the new system the entire population was entitled to medical services, together with prescribed medicines or appliances, wholly at public expense. Doctors who agreed to work under the scheme were paid on a *per capita* basis for the number of persons on their rolls; hospitals and training centres received direct government support. Doctors continued to be free to offer private medical services for a fee, and patients were free to purchase such services outside the scheme if they so desired.

The comprehensive programme inaugurated in Chile in 1952 illustrated the manner in which a variety of approaches were made part of a single system involving all elements related to the problem. The Chilean National Health Service, responsible for all public health services and for the medical care of three-fourths of the population, incorporated the following previous programmes: the government's public health responsibilities, medical care and sickness benefits under the compulsory insurance programme covering workers and their families, a system of public hospitals originally developed by private philanthropy and increasingly supported by public funds, the national services to children, and a public research institute. The governing body included representatives of the medical profession, the university faculty of medicine, employers' associations and trade unions. The programme was administered through a decentralized system of health centres operating public health and medical care services, under medical officers assisted by a team of social workers and other health workers and advised by local councils.

The health programme of the Soviet Union was an integral part of the effort to develop the nation's resources—in this case its human resources. All medical services were provided free on a public health basis and preventive and treatment services were combined throughout the system.

Comprehensive coverage was achieved in urban areas by sectional doctors or hospital externes assigned to a neighbourhood where they not only responded to calls for service but maintained constant health surveillance of certain categories of people such as young children. Factories maintained health posts to provide emergency treatment, as well as to supervise sanitary conditions and conduct health education in the shop. Larger industrial establishments had medical departments offering clinic and hospital care and in some cases they maintained night sanatoriums where workers who were well enough to remain on the job received treatment and slept. Smaller factories depended upon health centres maintained by local hospitals. Special dispensaries for a wide range of diseases were attached to local hospitals, which also furnished

in-patient specialized care. Maternal and child health services included pre-natal clinics where expectant mothers not only received care but also instruction in psychological attitudes and physical exercises designed to make possible painless births. In 1955, 92 per cent of all urban births occurred in maternity hospitals.

For the rural areas sectional hospitals with out-patient consultation served their respective areas, supplemented by maternity stations in each large village and maternity homes on many collective farms. Rural patients could take advantage of specialized services offered in regional and central city hospitals.

Special child health services were provided for each age level. The young children of working mothers received care in day nurseries in factories and on collective farms. Physical fitness programmes were conducted in schools and youth organizations. A network of rest homes provided healthy holidays for both children and workers.

Through programmes such as those of Britain, Chile, the Soviet Union, and similar plans in other countries, the economic barrier to medical care was reduced or eliminated in most of the economically developed countries, and the economically less developed areas were instituting similar programmes as fast as their national resources would permit.

IV. INTERNATIONAL CO-OPERATION IN THE FIELD OF HEALTH

Health was a matter of international as well as national concern, and the scope of health programmes broadened at this level as it did within countries. Early international health measures had been directed against the spread of pestilences, by means of quarantine conventions and agreements relating to the control of ports. As rapid travel brought all parts of the world closer together, control became more and more essential, for plane passengers could easily be carrying a recently contracted disease in the incubation stage. The League of Nations health office established international standards for immunization procedures and for the preparation of vaccines such as that for yellow fever. International trade in foodstuffs required standardized regulations relating to such matters as chemical residues from sprays or chemical additives to preserve the product. So long as foci of infection persisted anywhere in the world, the self-protection of all countries required their co-operation in campaigns for eradication.

The development and dissemination of medical knowledge, spread of public health practices and international attacks on specific diseases were greatly stimulated and promoted by the International Health Commission (later known as Health Division and Health Board) of the Rockefeller Foundation. From 1913 on, this privately supported foundation worked successively on one world-wide scourge after another, helping to discover, develop and demonstrate means of control and co-operating with governments in putting control programmes into effect. Its first attack was on hookworm, which

debilitated millions of people in warm climates; the campaign for sanitary measures to check infestation by this internal parasite extended into fifty-two countries. In its intensified attack on yellow fever, begun in 1914, it dared to conceive of a world-wide campaign which would wipe the disease from the face of the earth—the first such imaginative approach to disease control, though one doomed to disappointment because of the reservoir of yellow fever among jungle animals.

Work on malaria control was extended from the United States to Venezuela in 1921, then to Brazil and then to many parts of the world, where the Foundation established training stations, offered fellowships to train for malaria control posts and aided governments in setting up programmes, which were particularly successful in Italy and Portugal. Basic work on typhus, rabies, yaws, tuberculosis, the snail-borne parasitic infestation schistosomiasis and other widespread and stubborn diseases laid the basis for control techniques; a combination of training programmes and co-operative work with governments helped to put controls into operation.

Recognizing that the success of public health measures depended upon the presence of trained personnel, the Foundation financed the establishment or expansion of schools of public health, first in the United States and then in many other places, as in São Paulo, Brazil, and Prague, Czechoslovakia. It also provided international fellowships for advanced study at these centres. By the 1950s the more than 3,000 men and women who had been trained in public health with the aid of these grants were occupying key health posts in nearly every part of the world. The existence of this corps of internationally trained people in public health was a major factor making possible the spread of health knowledge and practices at a revolutionary rate in the decade after the second world war.

Direct international co-operation in the field of health was carried on between individual countries and through professional organizations. The socialist countries of east Europe and the Soviet Union entered into annual agreements for co-operative programmes in medicine and public health designed to share advances in these fields and to take advantage of the extensive development of medical training and public health facilities in the USSR.

At the end of the second world war the United Nations Relief and Rehabilitation Administration (UNRRA) set up a Health Division to combat the menace of post-war epidemics, to restore health departments, provide medical supplies and train personnel. This was by far the largest international health organization the world had known; it was followed by the establishment of a permanent United Nations health agency, the World Health Organization, created in 1948.

In contrast to the health organization of the League of Nations, which had concerned itself mainly with controls in relation to international trade and travel and with the standardization of procedures, WHO engaged in direct assistance to countries for the development of their health services. The scope

of its international aid included the development of public health services relating to sanitation, immunization, health education, hospital and clinic care, health statistics and reporting systems, health surveys, epidemiology; standardization of biological preparations; aid to medical research on specific problems; and the training of health personnel—doctors, nurses, sanitarians, auxiliary health workers.

International co-operation in the field of health also took the form of working together to cope with new problems. At mid-century the problems presented by the use of nuclear energy and danger from radiation were uppermost. A new phase in international health efforts was foreshadowed in the mid-1950s as WHO began to be concerned with what had become the major health problems of the developed countries—heart disease, cancer and other chronic ailments, and with measures designed to promote positive health.

V. EXTENSION OF MEDICAL KNOWLEDGE AND HEALTH PRACTICES TO UNDERDEVELOPED AREAS

Up to about the beginning of the second world war the application of medical science to the control of health was largely limited to the industrially developed countries. Elsewhere modern health practices were known and modern medicine was practised almost entirely in the major cities and among the Europeanized segments of the population, except for mission hospitals or missionary doctors.

In the years after the second world war, however, the picture changed drastically. As a central part of their movements for national development the non-industrial countries promoted national health programmes to spread medical knowledge throughout the population, reduce infant mortality, control communicable diseases and raise the general level of health. The most dramatic changes in health status during these years came in the underdeveloped areas. Death rates, and especially infant mortality rates, dropped in a decade as much as they had in western countries during fifty or more years. Deaths from diseases subjected to intensive campaigns dropped spectacularly. In Ceylon, for example, the general death rate fell from 22 per 1,000 in 1945 to 12·6 in 1950, largely as a result of an intensive campaign to control malaria.

1. *Reduction in mortality and control of major diseases*

The major health efforts in these areas followed the course which had brought health improvement in the western regions, but at an immensely accelerated pace and with the advantages of modern medical knowledge and the experience of the areas where many diseases had been brought under control. These countries directed their first and major attacks against the communicable diseases which remained their principal killers. Systematic measures were launched to eliminate pestilences where they were still endemic—plague and cholera in India, yellow fever in South and Central America, smallpox in all regions.

The governments of these countries sought and received the assistance of WHO in campaigns to eradicate yaws by the mass examination of whole populations and penicillin treatment of those found to be affected, in tuberculosis control, chiefly through mass programmes for vaccination of the child population with BCG vaccine, and in malaria control programmes to eradicate the disease and its carrier completely wherever this appeared possible and to introduce control measures where no efforts had been made in the past. In addition some countries sought assistance in controlling particular communicable diseases of importance in the area, such as trachoma in the eastern Mediterranean, leprosy in a number of countries and parasite infestations such as bilharzia and hookworm where these were a serious problem.

Maternal and child health services were second only to the control of communicable disease in the health programmes of many countries. In this field, the United Nations International Children's Emergency Fund (UNICEF) furnished very substantial aid, helping to train midwives, furnishing milk or stimulating its local production and providing specialists in child health to guide the development of local services and to train local personnel. WHO assisted in organizing such programmes and training needed personnel, both in countries such as Afghanistan where no such service had existed before and in places like India where services existed but extensive training and organization were required to extend them widely through the population.

In many areas improved health depended on better nutrition. Maternal and child health programmes stressed infant feeding, and UNICEF aid in supplying milk lent powerful support. In regions, especially in Africa, where the protein-deficiency disease generally known as *kwashiorkor* attacked many young children at the time when they were weaned, special efforts were made to overcome the inadequacy of the adult diet to which the child was shifted. General improvement in nutrition, however, was pressed with less vigour than attacks on communicable disease and was making slow headway against the hold of traditional food patterns.

For many of the underdeveloped countries environmental sanitation and basic health education were among the most essential needs, but practical difficulties and deeply ingrained habits presented serious obstacles. Whereas in the western areas general sanitary conditions had been achieved before direct control of many diseases by drugs or immunization became possible the situation was reversed in some of the underdeveloped countries. Environmental sanitation tended to lag behind while advanced techniques, such as BCG vaccination or treatment with penicillin, were being introduced. In the effort to strengthen programmes of sanitation and to stimulate their spread, WHO provided technical assistance in this field to the governments of several Asian and eastern Mediterranean countries, and the large number of fellowships which it offered to Africans in the 1950s were for this purpose.

In the development of health services and campaigns to combat disease underdeveloped countries were severely handicapped by shortage of personnel

and inadequacy of training facilities. New medical schools were established in many countries, but they faced serious difficulties in maintaining adequate teaching staffs when the limited number of doctors and nurses were in great demand for direct medical practice and the administration of health agencies. International co-operation in medical and nursing education, and in training of laboratory technicians, helped to provide the manpower without which health programmes could not go forward.

WHO recognized that mass programmes for the improvement of health would have to be carried in large measure by auxiliary workers since no programme of professional training could be expected to provide sufficient professional personnel in the foreseeable future in regions of Africa and Asia where there were as few doctors as one per 50,000 of the population. It therefore undertook to suggest standards for such auxiliaries, to guide plans for training and to conduct experimental programmes to demonstrate their effective uses. One such WHO-aided demonstration programme, in El Salvador, set up a pattern of service which could be repeated throughout the country with the limited financial and other resources available. It included rural health posts manned by nurse-auxiliaries visited by a doctor periodically, village and town clinics with minimum essential facilities where much of the responsibility was carried by the public health nurses, and an area health centre where the doctors who attended the clinics and health posts were based, nurses and auxiliaries were trained, the sanitary inspector had his office and some hospital services were provided. Newly trained nurses and auxiliaries and young doctors assigned for public health experience were used to staff the demonstration area, while those who had already acquired experience within the area were transferred by the health department to establish similar health services in other parts of the country.

The importance of the social component in health was recognized in all these programmes. Medical social workers were frequently included in health teams, and even the restricted training given to auxiliary workers included instruction in some of the social factors which could be expected to affect the way in which health education would be received and the willingness to make use of health services or co-operate in health programmes. In general, while some popular resistance to modern health practices was encountered the eagerness to respond to life-saving measures was evident everywhere.

For underdeveloped areas the cost of medical care was an even more serious problem than in the developed areas. Because of the extreme poverty of the vast majority of the people and the high cost of modern medicine, most health services had to be provided through public funds. In some countries, particularly in South America, medical care for industrial and some agricultural workers, together with some care for their families, chiefly maternal and infant care, was developed through social insurance to which the employers contributed most of the funds, supplemented by grants from the state. Everywhere costs imposed a limitation on the expansion of services and gave special

importance to preventive and mass protective measures rather than to facilities for individual care. The more immediate needs for rapid training and the development of services as quickly as possible tended to receive support in preference to the medical research and professional development essential to a high level of health services in the longer run.

The great problem facing these areas, along with the question of how heavily to invest their limited means in the costly provision of modern health services, was whether the development of their economy could keep pace with improvements in health, how far such improvements would themselves contribute to greater productivity, and whether their basic resources would be sufficient to sustain the lives which medical science would save.

2. *Replacement or incorporation of native medical traditions*

Some countries, notably India and China, possessed an ancient medical tradition unrelated to the scientific knowledge on which modern medical practice was based. Elsewhere, as in parts of Latin America, Africa and the Pacific, various types of medicine men, *curanderos* and witch doctors were the traditional practitioners of the healing art.

When western medicine first reached these areas, those whose practice was based on scientific knowledge scorned native medicine as superstitious and its practitioners as ignorant. Traditional medical systems persisted, however, into the mid-twentieth century. In India the Benares Hindu University maintained a school of Ayurvedic medicine in which professionals were trained in ancient techniques. In the Chinese People's Republic patients could choose a traditional or a modern doctor in many places. In many other areas, such as the region of the Andes, the West Indies or parts of Africa, people patronized both the modern doctor and the medicine man according to their ailment.

In the course of time some western-trained medical men revised their completely negative attitude toward these indigenous medical systems. Some of the traditional forms of treatment turned out to be sound by scientific standards. The discovery of penicillin, for example, validated the traditional Chinese practice of using certain natural moulds against infection in open wounds. A traditional Indian drug was found to be more effective in certain cases of hypertension than anything known in the West and was introduced into general medical use. Western-trained doctors practising in areas where a strong local medical tradition existed found it practical to use their diagnostic skills to determine the nature and gravity of the illness, and then to prescribe the familiar local drugs or other treatment if the case was not serious, reserving the limited supply of expensive modern drugs for cases where these appeared to be essential to recovery. In 1955 the Indian medical profession undertook a systematic analysis of the medication prescribed by the Ayurvedic system in order to ascertain the chemical properties and method of action of the traditional remedies and to make possible the incorporation of this knowledge into general medical practice.

Moreover, as western-educated doctors learned more about the importance of psychosomatic factors they came to realize that indigenous medical systems had often taken these elements effectively into account. Psychiatrists began to study the methods used by tribal witch doctors and to find evidence of procedures similar to their own, often at a highly sophisticated level.

Practitioners of traditional medicine, on their part, adopted many features of scientific medical practice. *Curanderos* added penicillin to their kits. Traditional midwives accepted training in aseptic procedures. At the Ayurvedic medical school of Benares Hindu University the surgery which was taught was the same as in other medical schools.

It appeared likely that the process of interchange, along with continued advances in scientific medical knowledge and the spread of medical services, would lead to amalgamation, just as the formerly rival systems in the West had already become a single system of world-wide medical practice.

3. *Impact of health practices: case example of Puerto Rico*

A vivid illustration of the process by which the application of health knowledge was remaking the societies of underdeveloped areas was furnished by the commonwealth of Puerto Rico.

At the opening of the century the island of Puerto Rico was typical of most of the tropical and subtropical regions of the globe, with a life expectancy of 36 years, an infant mortality rate of approximately 200 per 1,000 live births, all the familiar water-borne, insect-borne, infectious and contagious diseases, and a general death rate nearly double that of western Europe and North America at the time. In 1930 average life expectancy was still only 41 years. On the eve of the second world war the situation, though materially improved, remained that of a 'backward' area; life expectancy had advanced to 46 years and infant mortality had dropped to 113 per 1,000 births, but the leading causes of death were still diarrhoea and enteritis, tuberculosis, malaria and other communicable diseases.

By 1955 the death rate in Puerto Rico at most age levels was as low as that of the continental United States and many European countries, although the infant death rate still remained somewhat higher; the traditional killers had been brought under control and some virtually eliminated; deaths from tuberculosis had dropped from 260 per 100,000 in 1940 to 34 in 1955; no death from malaria was recorded in that year, only one from typhoid fever and a handful from childhood contagious diseases; the leading causes of death had become the same as those in the developed countries—heart disease and cancer. In fifteen years, average life expectancy had risen from 46 to 68 years.

The health record of Puerto Rico reflected the direct application of medical knowledge and the indirect effect of changing economic, social and educational conditions throughout the commonwealth.

At the opening of the century public health measures were directed primarily at the control of major contagious diseases, i.e. inspection of vessels

in port and wholesale vaccination to combat smallpox. Medical care was provided efficiently to those who could pay, by private physicians trained abroad, located in the principal cities; the masses of people were served in an inferior manner by politically appointed municipal doctors whose cursory treatment and insanitary hospitals were the butt of prevailing jokes.

Systematic measures to reduce disease and promote health began to take shape in the 1920s with the beginnings of sanitary controls in the principal towns, the destruction of mosquito breeding places to reduce malaria, and the first maternal and child health dispensary, established by the Red Cross in 1921 and then taken over by the public authorities. In the mid-twenties the health department, following a visit of its commissioner to observe public health services in the continental United States, began to establish local public health units consisting generally of a maternal and child health clinic, clinics for venereal disease and tuberculosis, and a centre for health education. In the following decade such units were set up throughout the country and brought health services and health education within reach of people in all areas.

From 1940 on, Puerto Rico intensified its attack on health problems across a broad front. In that year it established a special venereal disease bureau, enlarged its maternal and infant health services, set up a programme for crippled children and organized a nutrition division in the health department. Medical social workers were added to health services in 1942, and in 1944 a special bureau of health education was created in a determined effort to reach the people. A special unit focused the attack on hookworm. Rapid treatment of venereal diseases with penicillin was started in 1945 and the use of DDT spray against malaria in rural areas the following year. Special divisions of the sanitary bureau were created to deal with industrial hygiene, rat control and the prevention of typhus, the contamination of water and disposal of industrial waste, and a drive for sanitary conditions in restaurants was launched. In 1949 mass vaccination with BCG vaccine was begun, and the following year treatment of tuberculosis with the new drugs was started experimentally. When in 1952 a new 800 bed tuberculosis sanatorium was opened, drug treatment of ambulatory patients had already started to replace bed-rest in sanatoriums as a preferred form of treatment, and the number of tuberculosis deaths and new cases had started to drop precipitately. Growing concern with chronic diseases was reflected in the establishment of a bureau for cancer control and the inauguration of a mental health programme in 1950.

In order to make more adequate care possible for all, the University of Puerto Rico established a medical school in 1941. The state provided a generous programme of scholarships for medical training, and the health department constructed a series of well-equipped district hospitals to supplement the inadequate care offered by the municipalities. In 1949 the department took the further step of bringing together in the first of its combined health centres the public health unit with its maternal and child health, venereal disease and tuberculosis clinics and health education programme, the municipal hospital

and general medical consultation, the sanitary inspectors, vital statistics office, public health nursing service, child welfare and public assistance offices.

Eight years later, when such combined centres were in operation throughout the island, the local health centres began to be integrated with the district hospitals in a regional organization designed to make the best use of specialized facilities, to keep the personnel of the local centres at a high level of proficiency by making them part of a single regional staff, and to achieve a further co-ordination of preventive and treatment aspects. To provide the whole system with the highest professional and technical leadership, the fine new tuberculosis sanatorium, no longer needed for its original purpose, was converted into a medical centre which included medical research institutes and a teaching hospital for the university medical school.

The improvements in health during these fifteen years could not be attributed solely to the expansion of health services, for many other developments were changing the environment and contributing to general health. Aqueducts carried pure water to all urban areas and began to penetrate the rural zones; in some places clean supermarkets took the place of many of the often-insanitary little food stores; latrines constructed under the stimulus and inspection of sanitary officers reduced the spread of hookworm and bilharzia in rural areas; school lunch programmes and breakfasts for pre-school children raised the level of general nutrition. In the course of these years the average height and weight of students entering the university rose noticeably, and differences in size which had clearly distinguished lower- and upper-class children were no longer apparent.

Medical services developed under public auspices were offered to all people of limited means without charge. Well-to-do families continued to pay for the services of private physicians, either directly or through private hospital and medical insurance schemes. With the growth of a middle class able to meet some of the costs of medical care, the question of financing part of the general programme of health services on the basis of compulsory health insurance came under discussion.

The successful battle for health and survival brought to Puerto Rico the social consequences common to underdeveloped areas with rapidly declining death rates. The direct result in the vigour and productivity of the people could not be readily determined, but it must have been considerable. The effect upon the population balance was clear. In contrast to the developed countries where the slow reduction in mortality over a hundred years had been accompanied by a falling birth rate, death rates here dropped almost overnight, while birth rates showed relatively little change. By 1955 there were nearly five births in Puerto Rico for every death. Whereas the rate of natural increase during the first five years of the twentieth century had been 1·1 per cent per year, in the years 1950–54 it was 2·9 per cent and the birth rate was still nearly double that of most of the industrial countries. Heavy emigration drew off much of the increase, and enabled a vigorous national programme of

industrialization to raise *per capita* income. But in a country which ranked in population density with Java and Japan, the achievement of a healthy population in less than a generation precipitated dramatically the problem of population balance which faced so many parts of the world.

VI. POPULATION

1. *Acceleration of population growth*

The great success of the attack on the causes of death brought a radically new population pattern to the world, for it produced a rate of population growth far greater than any which the world had ever experienced. In the mid-1950s the world's population was approximately 2,500 million; at the opening of the century, it had been approximately 1,500 million. Growing at the rates which characterized the 1950s, it would reach about 4,000 million by 1975 and 6,500 million by the year 2000, according to United Nations estimates. The rate of growth in the 1950s was nearly double that of the years from 1900 to 1950—1·6 per cent per year from 1951 to 1955 as against an average of 0·9 per cent for the half century. And the growth in the first fifty years of the century had already greatly exceeded any previous period; in the last half of the nineteenth century the rate had been only 0·6 per cent.

This tremendous burst of population growth was a new phenomenon in the life of mankind. Rough estimates place the world population at about 1,200 million in 1850, 750 million in 1750, 500 million in 1650 and perhaps 250 million at the opening of the Christian era. Throughout human history the population of the globe had grown unevenly, unsteadily and in different regions, expanding as men learned to command the earth's resources and cut back by pestilence, famine, violence or the disruption of established societies. Pressure of population had long been known in specific regions such as the valley of the Nile. Recurrent migrations of peoples had reflected the quest for living space.

But never before had the rate of increase begun to approach that of the mid-twentieth century and never before had the whole world faced the prospect of the filling up of open spaces, the crowding of ever-expanding cities, the pollution of streams, lakes and shores, and the need to expand the output of goods and services at an impressive rate even to maintain existing levels of living. And never before had the people of the world—the new millions born each year—needed so much material equipment, so much education and such a complexity of organization to enable them to function in the world into which they were born. Nor had any earlier age begun to match this in the technical resources for meeting these needs.

The high rate of population growth presented the world with a series of critical problems: competing demands for the use of resources—the claims of the 100,000 or more babies that were being born every day in the 1950s for

food, shelter, care and training as against other claims, including those of industry for capital expansion; the prospective size of the world's population as for the first time in human history it became necessary to consider what practical limits the earth's total resources might place on the ability to sustain human life; and the effect of population growth on the interrelations among the world's peoples as it widened disparities in levels of living and set in motion pressures which could lead to conflict.

Even before the spectacular success of death control triggered the population boom of mid-century, population had been recognized as a world-wide problem calling for scientific study. An International Union for the Scientific Study of Population was formed in Paris in 1926, following the first World Population Congress in Geneva the preceding year. Health statisticians took the lead in this movement, joined by social scientists who were concerned with the economic and social aspects of population change, and by actuaries who needed a basis for estimating likely claims for life insurance benefits.

As governments all over the world improved their collection and publication of vital statistics and other population data, it became possible to make more systematic comparative studies. Recognizing the many influences on population growth, demographers analysed a multiplicity of factors affecting trends and developed demographic principles. These scientific studies laid a factual and analytical basis for the development of public policy when the dramatic tendencies of mid-century made population a national and international issue. The international importance of the problem was attested by the inclusion in the structure of the United Nations in 1945 of a special Population Commission, on a par with the commissions on Status of Women and Human Rights.

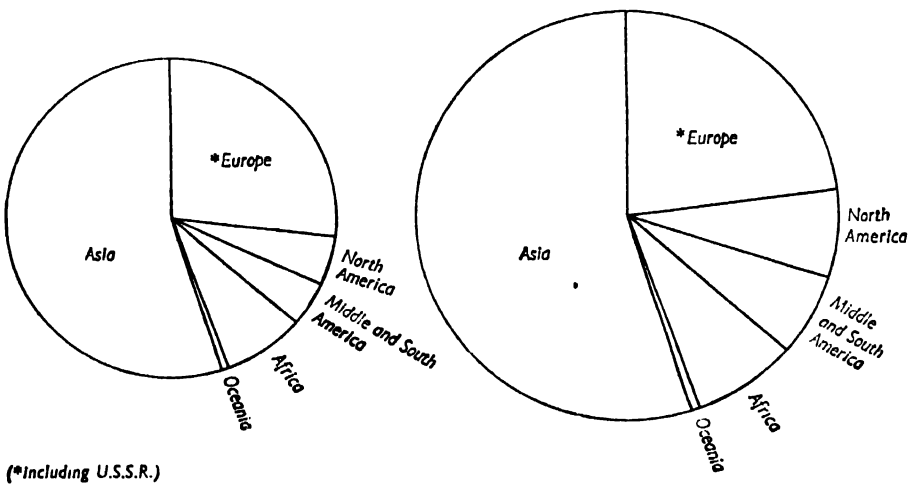

CHART XX. World Population, 1900 and 1950. Percentage Distribution by Continents.
Source: UN, *Future Growth of World Population*, 1923.

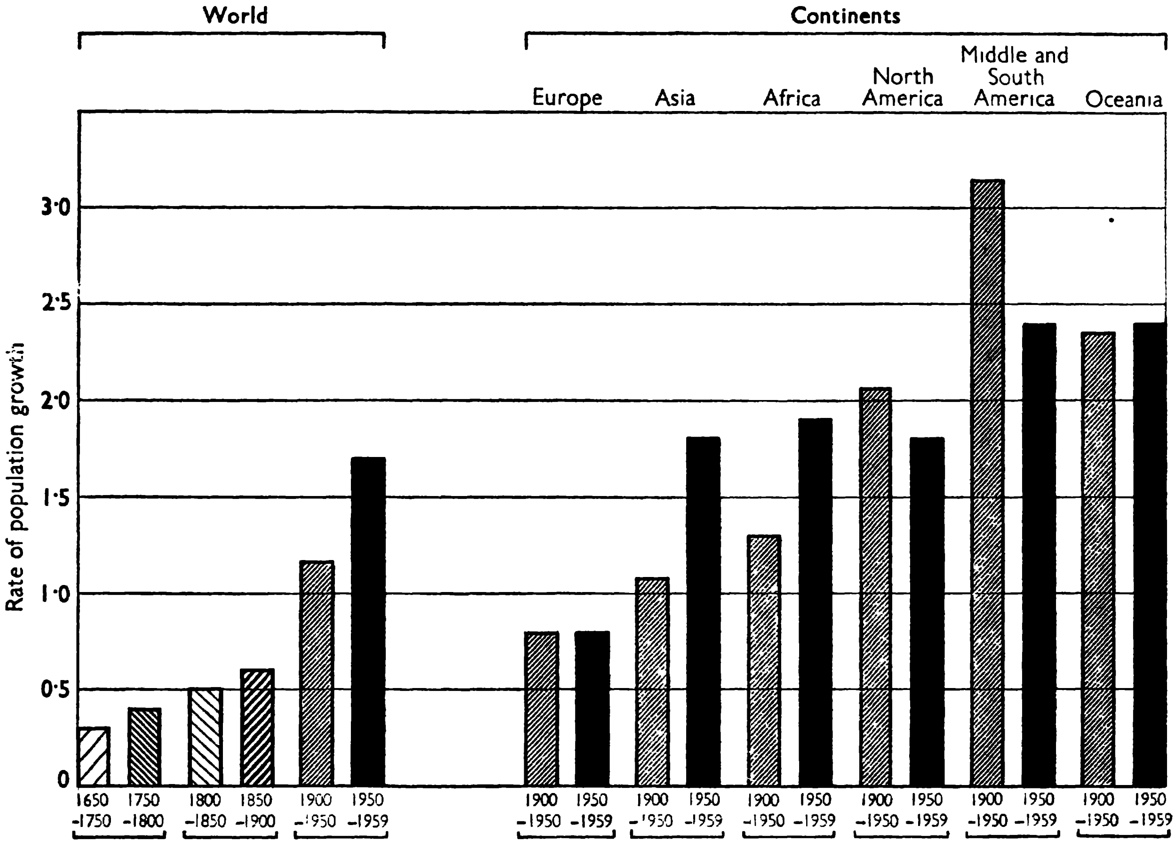

CHART XXI. Rate of Population Growth by Regions.

Source: U N, *The Determinants and Consequences of Population Trends; U.N. Statistical Yearbook*, 1960.

2. High rates of growth in underdeveloped areas

The rapid population growth of the mid-twentieth century came mainly in economically underdeveloped areas. In these regions high death rates had formerly balanced high rates of birth, so that population growth had tended to be slow or erratic, increases not infrequently alternating with decreases brought on by disasters. The Latin American countries had already begun to experience an acceleration in their rate of natural increase before the second world war, as mortality declined while birth rates remained high. In the years after the war the tendency was carried further in that region and was extended to large populations in Asia and to a lesser degree in Africa. The estimated annual increase in Latin America in the 1950–55 period was 2·4 per cent as compared with 1·9 per cent before the war. Even higher rates were recorded in some Latin American and Asian countries such as the Central American Republics and Ceylon.

The upsurge in population in the underdeveloped countries reflected mainly the application of mass methods for checking epidemics, controlling infectious diseases such as malaria and reducing infant mortality; it was not necessarily associated with any rise in the economic capacity or level of living of the peoples involved, and it therefore enhanced the economic and social difficulties faced by these countries.

The first problem faced by these countries, especially in areas where hunger was already endemic, was the relation between food supply and the number of mouths to be fed. This was a problem which had concerned European thinkers from the beginning of the nineteenth century and which had produced two general and opposing views, those of Thomas R. Malthus (1766–1834) and those of Karl Marx. Malthus held that population tends to outrun food supply, for, he thought, it increases geometrically while food increases only arithmetically; population therefore has to be checked by pestilence, war and famine unless controlled by the exercise of 'moral restraint'. Marx maintained that once men were freed from the hampering institutions of capitalism there would be no limits to the productivity which they could achieve and hence that population presents no problem in a socialist society.

The historic situation in the nineteenth and early twentieth centuries—improved technology and the opening of virgin lands—expanded both the food supply and the general economic base for larger populations; as a result the danger which Malthus stressed appeared not to be very real. Opportunities for emigration relieved the pressure in heavily populated areas such as Italy. Moreover, 'moral restraint' came into play and the birth rate dropped in Europe and North America so that the rate of increase remained well below that of expanding food supplies. Even so, aggressively expansionist countries such as Japan and Nazi Germany sought to justify their thrusts for territory by the claim that their populations needed living space.

The spurt of population in the underdeveloped countries raised anew the

problem of whether population growth would outstrip food supply. Careful appraisals of possible food production, such as those by the geochemist Harrison Brown in *The Challenge of Man's Future* (1954) and by the British organization, Political and Economic Planning (PEP) in *World Population and Resources* (1955), reached the conclusion that double the existing world population could be fed if the best known techniques were applied to the land and waters then in use and to new areas which could be brought into cultivation. At the rate of increase then prevailing, a world population of that size would be reached in some fifty years. If radically new techniques should be developed and extensively used, such as the production of protein by the cultivation of algae or by chemical synthesis, food supplies might be sufficient for still larger populations.

But whatever might be the theoretical possibilities for feeding an enlarged world population, all the world's food production was not in reality available to those who needed it. While North American farmers found difficulty in marketing their surplus products, perhaps half of the world's people were living below a minimum nutritional level, many in a state of chronic hunger. In spite of vigorous programmes for increase in food production, *per capita* food consumption in Asia in 1955 outside the USSR was still below what it had been before the second world war. India struggled desperately to step up its output of food to get ahead of its population growth. China, committed to the Marxian view that socialist reconstruction of society could meet the needs of people in spite of population growth, took heroic steps to expand food production to feed its vast population and the fifteen or more million new mouths added each year.

The effect of population growth on economic development, however, involved more complex relationships than the equation between numbers of people and supplies of food. These relationships presented problems in socialist as well as capitalist economies, although socialist authorities regarded them as wholly soluble under their system. The need to use resources for capital formation in order to lay the basis for expanded production was competitive with the need to devote resources to education and housing. Different age structures affected the productive capacities and the consumption needs of a country. Any major change in population modified the internal balance of the society. Responsible leaders saw the need for measures which would keep population in line with other aspects of development in order to permit balanced growth.

A health official of one of the richer countries of South America, Venezuela, might have been analysing the problem in all the underdeveloped areas when he said of his own country in the late 1950s:

'Our successful campaign to reduce infant mortality has given us more problems. If we do not have adequate food supplies at reasonable prices and an understanding of nutrition, the babies we save may sicken or die of mal-

nutrition before they reach school age; when they reach school age, there will not be enough schools, unless we can greatly expand our educational facilities; if they lack schools, they may become juvenile delinquents and present us with still other needs for services; if they reach working age without sufficient training, they will not earn enough to give their own children a good home—even if we manage to get enough housing built; and whether they will find jobs at all will depend on the rate at which we can expand our industry and improve our agriculture, and find the capital resources with which to do so. Unless we can move forward on all fronts at the same time, the saving of lives only puts us further behind.'*

The poorer the country and more limited the resources, the more difficult it was to meet simultaneously the needs of a rapidly growing population and of an economy which must be expanded still more rapidly. Even such a country as Brazil with vast untapped natural resources and the capacity ultimately to absorb a very much larger population found its efforts to achieve economic development and overcome its heritage of mass poverty complicated by its high rate of population increase. In India, where population pressure was already severe in many areas, national leaders recognized that unless the rate of population growth could be slowed there would be small chance of achieving the economic expansion which alone could lift the masses of the people out of hunger and poverty—yet India's rate of increase in the 1950s was not as high as that of many other underdeveloped areas.

On the positive side, reduction in mortality meant tremendous savings in the social cost of premature death, i.e. the cost to society of rearing children who failed to live long enough to repay the cost of their nurture through their own labour; even in the United States, with a relatively low death rate, the cost of premature death in 1950 was estimated at something like 3·5 per cent of the national income. But on the other hand the great increase in the number of children who survived placed a growing burden on the adult population, for it resulted in a higher ratio of dependent children to adults of working age than in countries with relatively stable populations. In Britain in 1950, for example, every ten adults of working age were supporting an average of five and a half children, whereas ten such adults in Brazil would have on the average more than eight children dependent on them.

Moreover, employment opportunities would have to expand as fast as young people reach the age to go to work. With annual rates of population increase of 2 and even 3 per cent, a corresponding rate of economic expansion would be required merely to prevent the economic situation from deteriorating. Yet even in the economically developed countries an annual rate of economic expansion exceeding 3 per cent over a long period was high. Any such rate of expansion required much capital to invest in industrial expansion; but

* Personal interview with Dr Espiritu Santos Mendoza.

in countries of low *per capita* income lack of capital was one of the most difficult obstacles to overcome.

The problem of sufficient capital formation was further intensified by the need of the increased population for housing. With people already seriously under-housed, the economically developing countries faced a most critical housing problem, for efforts to provide shelter for their additional families, even at prevailing low levels, competed for the limited supply of capital goods needed to expand economic production.

The difference in rate of population increase between the underdeveloped and industrially developed areas, moreover, tended to increase the disparity between the 'have' and the 'have-not' countries. At best the underdeveloped countries faced a difficult task in attempting to catch up with industrially developed areas whose capital, know-how and institutions gave them the basis for continued or accelerated economic growth. To the extent that the need to support and train a constantly expanding population acted as a drag on the developing countries while no corresponding drag held back the others, it stood in the way of their best efforts to close the gap that separated them from those who enjoyed an industrial head-start.

3. *Reduction in mortality and control of natality*

The drop in death rate in underdeveloped countries in the mid-twentieth century had a more disturbing effect than the corresponding drop which had occurred in the West, primarily because the decline came so rapidly and because there was not a corresponding drop in rate of birth.

In Europe and other western countries birth rates had fallen during the hundred years from 1850–1950 either at the same time that death rates were falling, as in France, or with some lag, as in Germany and England in the last quarter of the nineteenth century, and the process had continued over a long period. Methods for the control of natality were known and practised in western countries, more generally among families of higher economic and social levels and more education, but widely and increasingly by all levels in the population. Lowered birth rates were associated with urbanization, for fertility tended to decline further in large cities than in rural and small town areas. The birth rate also tended to fluctuate with economic conditions, falling to a low point in the depression of the 1930s.

Some signs began to appear that birth rates might eventually follow a similar course in the developing areas. In Puerto Rico the crude birth rate which had fluctuated around 40 per 1,000 for two decades dropped steadily in the 1950s to 34 in 1955 and 32·6 in 1956, though the latter rate was still higher than the rates which had prevailed in the United States and western Europe in 1900. But only in Japan, where drastic measures were undertaken after the second world war, was there a drop in natality comparable to the precipitate drop in mortality.

Spread of knowledge and the practice of birth control met with considerable

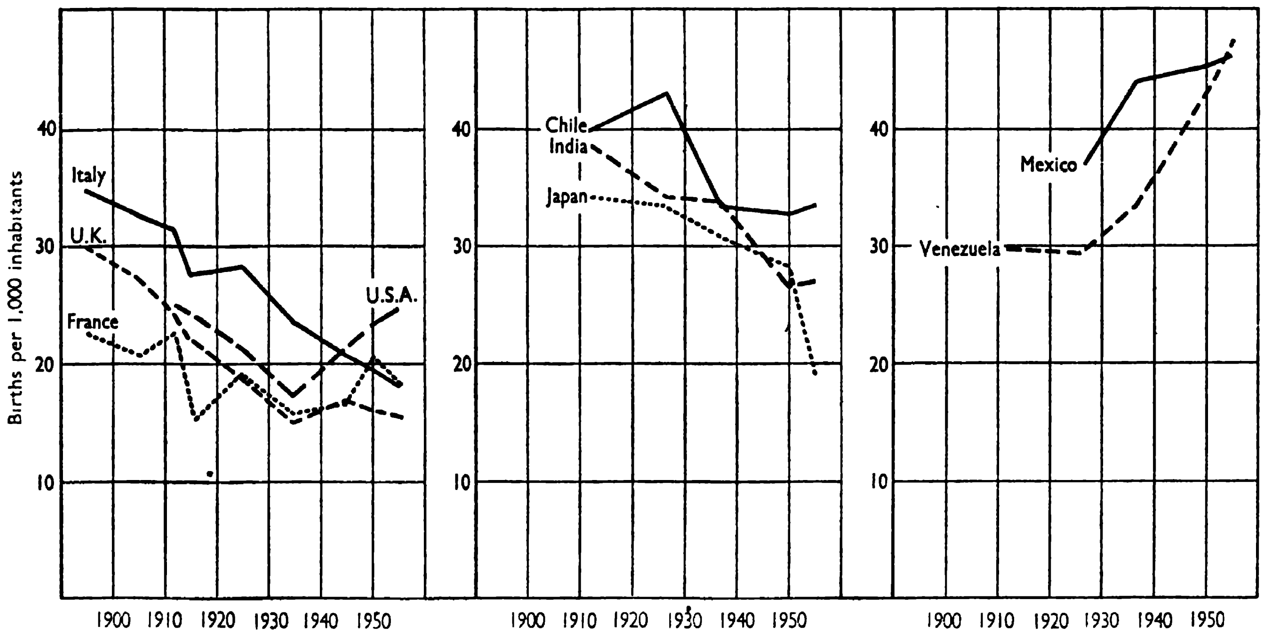

CHART XXII. Changing Birth Rates, 1900–55; trends in Selected Countries. Births per 1,000 Inhabitants.
Source: Woytinsky, *World Population and Production*, pp. 144, 149; *U.N. Statistical Yearbook*, 1960.

cultural resistance in many areas. Acceptance of children as an expression of the will of God was widespread, although in areas where a rationalist, scientific mentality and climate of opinion prevailed such an attitude ceased to be general. Some religious attitudes stood in the way. The Biblical admonition to 'be fruitful and multiply', the Muslim value attached to many sons, the traditional Chinese need for descendants to carry on respect for the ancestors and the religious connotation given by Hinduism to the act of creation all reinforced the natural desire of men and women for children. The principal opposition to the practice of contraception as such came from the Catholic Church, which categorically opposed any so-called artificial means and countenanced only abstinence and the 'rhythm' method to achieve family planning. In some predominantly Catholic areas other factors appeared to be at least equally important in determining the extent to which births would or would not be planned, and disparity in the sizes of Catholic and non-Catholic families was generally not great at comparable economic and cultural levels. Catholic teachings did however exert a strong influence on political developments in this field.

The one country where control of natality rapidly restored a degree of population balance once mortality had fallen was Japan in the years after the second world war. At the opening of the century the birth rate in Japan was somewhat, but not markedly, higher than in western Europe and the United States, and it was below that of Russia and eastern and southern Europe. It did not fall but even increased somewhat during the decades when birth rates were declining in western Europe and the United States from close to 30 per 1,000 to less than 20, or as low as 14·5 in Sweden and 17·1 in the United States in the 1930s. It remained high after the second world war while the death rate dropped to one of the lowest in the world as soon as it ceased to reflect the immediate effects of the war. As a result the population started to shoot upward at double its pre-war annual rate of increase. Then the birth rate began to drop sharply. From 34·3 per 1,000 in 1947 it fell to 19·4 in 1955.

The swift reduction in the Japanese birth rate was brought about primarily by resort to abortion, since contraception was not widely practised in the country. In 1953 an estimated one out of every three pregnancies ended in abortion. Speaking at the World Population Congress in 1954 representatives of Japan explained that although abortion was not a preferred method, it was nevertheless permitted and made medically safe in recognition of the need to keep the population within bounds until such time as the practice of contraception should become sufficiently general to maintain balance.

Other Asian countries recognized their population problem as serious and initiated efforts to bring it under control. India made population control part of its official policy and sought means to implement it as essential to the success of its five-year plans. It included family planning in its mass education campaign and in its village development programme, making it a part of the reorientation of village people toward the desire for a better life and the idea

that improvement is possible. Pakistan showed similar concern. Although the Chinese People's Republic rejected the policy of population control, it made family planning a feature of its intensive public health programme in the interest of the health of mother and child.

But so long as the available means of contraception were costly and difficult to use, the chance that a rapid spread of knowledge would check rapid population growth seemed to be remote. Much medical research therefore was directed toward the quest for a cheap and simple method of preventing conception, experimenting with both chemicals and hormones. By the mid-1950s some progress had been reported. In the light of success along other lines, including the use of hormones to overcome sterility, it appeared probable that this problem also would yield to the onslaughts of medical science.

Yet simple means of birth control alone would not necessarily result in a slowing down of the rate of population growth. Personal attitudes and the stand taken by governments and religion played their part. Some national governments might be tempted to encourage population expansion for reasons of prestige and military strength even when economic and social considerations might dictate an opposite policy—witness the bachelor tax imposed by Mussolini in a country which had for generations supplied large numbers of emigrants because of pressure of population in the Italian peninsula. The position of the Catholic Church carried weight in the region of fastest population growth, Latin America.

On the basis of western experience up until the second world war it had been generally assumed that a rising level of living and increase in urbanization would have the effect of lowering the birth rate. By the 1930s such countries as France and Sweden were barely maintaining their population through natural increase.

After the war, however, birth rates rose and remained above their pre-war levels, especially in the United States and Canada where they were high enough to double the population of North America in fifty years, and in some European countries of very low rates, notably France. It thus appeared that although industrialization might result in reducing very high birth rates from over 40 per 1,000 to well below 30 as it had in the past, it could not be counted upon to bring the rate of population growth down to that which characterized Europe and North America in the first half of the twentieth century. The higher birth rates sustained in the industrial countries in the 1950s, in contrast to the drop which occurred following the peak after the first world war, suggested the possibility that once a high level of economic development had been maintained over a considerable period of time it might be reflected in a pattern of larger families than had seemed probable several decades before.

4. *Population as a world issue.*

The expectation of a more than doubled world population by the early years of the next century thus presented the problem of the kind of human

society that was in prospect. If world population should double again in the succeeding fifty years, tendencies toward congestion would mount geometrically. Cities could be expected to double in size or multiply in number; roads would cover the landscape carrying their ever-mounting loads of traffic; fewer and fewer water sources could remain untapped; open areas and wild life would continue to disappear and patterns of life in most of the world would have to be adjusted to new population densities.

Even with no change in living levels the pressure on resources would be tremendous. But the modern world was committed to raising the levels of living of its people. Success would mean still more food, more housing, more traffic and more drain on other resources than would result from the mere doubling or quadrupling of numbers at the levels which formerly prevailed. Failure could only mean frustration for masses of people, with whatever the consequences might be in the nuclear age. The issue presented by such rapidly mounting numbers, moreover, was not merely the capacity of the earth to satisfy material wants; it was also the capacity of men so to order their lives that they could live together in such numbers on the globe. In the final analysis the issue was the quality of human life itself that would be possible and the opportunities for its fulfilment and enjoyment.

The question of population prospects and efforts at population control became a highly controversial one in the 1950s. Since the sharp change in rate of growth came mainly in the underdeveloped areas, it was easy to allege that concern expressed in the industrially advanced countries was no more than an effort to maintain the privileged position of these countries against the 'have-not' peoples whose mounting numbers they feared. The strong emotions aroused by the position on birth control reiterated by the Catholic Church made it difficult to treat the issue dispassionately wherever the influence of the Church was felt. Similarly the Marxian insistence that population could be no problem under socialism threw the issue into the arena of conflict between those who followed and those who rejected this doctrine. And the fact that 'population' was not a matter which could be dealt with directly since it resulted from the actions of millions of people in their private lives led other people to insist that the whole question lay beyond the reach of public policy.

Yet thoughtful people all around the world were recognizing at mid-century that the new phenomenon of rocketing population was a major factor affecting the kind of life that might be foreseen for mankind in the years ahead.[1]

NOTES TO CHAPTER XV

The analysis of the Author-Editors is queried by Mario Bendiscioli, Silvio Golzio, and Vincenzo Cappelletti, who assert that 'in dealing with problems related to the increase in population' the authors are 'solely concerned with a study of the trend in demographic development and the demographic factors on which it depends'. The Italian commentators state that greater emphasis should have been placed upon 'the complexity of the inter-dependence between the dynamics of population and other components of the socio-economic system'. They believe that the text 'is one-sided in the manner in which it poses the population problem: it sees the control of births as the only possible solution, and attributes any other views to unscientific political and religious motives'. They go on: 'It is incomplete in that it ignores, except for two very brief allusions, the marked increase in per capita real income . . . during the last ten years in nearly all countries,' adding that 'This observation gains force if the recent results of research into the peaceful uses of atomic energy are taken into account. . . .' A somewhat similar view is expressed by Candidate of Medicine, Y. P. Lisitsyn, and Doctor of Medicine, B. Y. Smulevich:

'The whole discussion of the problem, based on neo-Malthusian theories, does not reflect the actual state of affairs. Soviet scientists maintain that the role of population growth as an economic factor is wholly subordinate to social-economic factors. . . . In socialist countries rapid population growth in no way interferes with the maximum satisfaction of the people's needs. On the contrary, it is a prerequisite of the further growth of production at accelerated rates and consequently of the improvement of public welfare.'

The Catholic position regarding population is defined in moral terms which regard certain forms of population control as sins against nature but which at the same time lay stress upon personal and social responsibility. The position with regard to birth control is defined in the encyclical *On Christian Marriage*, promulgated in 1930 by Pope Pius XI:

'But no reason, however grave, may be put forward by which anything intrinsically against nature may become conformable to nature and morally good. Since, therefore, the conjugal act is destined primarily by nature for the begetting of children, those who in exercising it deliberately frustrate its natural power and purpose sin against nature and commit a deed which is shameful and intrinsically vicious.'

In regard to the material means for sustaining a family, the encyclical places the responsibility first upon the parties to the marriage, then, if necessary, upon private charity and upon the state.

The Church does not directly oppose the idea of planning parenthood, Professor Emilio Pin explains; but it does condemn 'the motivations' and 'the means which are often linked to birth-control propaganda. These motivations and means are opposed by the Church as being selfish and immoral. If true social and moral reasons require limitation in the number of children, the Church does not oppose it, provided the means themselves are not immoral.' As a practical means the Church approves a so-called rhythm method of regulating births.

Increasing attention has been directed in Catholic circles to the social problems resulting from irresponsible parenthood and from rates of population increase in excess of the rate of economic development needed to overcome the burden of extreme poverty. Catholic leadership has joined with non-Catholic in seeking means which are consistent with moral principles to strengthen and apply personal and social responsibility in this field.

On the subject of population, the following works may be used to supplement the text:

Horace Belshaw, *Population Growth and Levels of Consumption with Special Reference to Countries in Asia* (New York, 1956).

A. J. Coale and E. M. Hoover, *Population Growth and Economic Development in Low Income Countries* (Princeton, 1958).

Committee on Science and Public Policy, National Academy of Science, National Research Council, *The Growth of World Population* (Washington, D.C., 1963).

Sidney H. Coontz, *Population Theories and the Economic Interpretation* (London, 1957).

Robert Carter Cook, *Human Fertility: the Modern Dilemma* (New York, 1951).

Hope Tisdale Eldridge, *Population Policies: A Survey of Recent Developments* (Washington, 1954).

Richard Martin Fagley, *The Population Explosion and Christian Responsibility* (New York, 1960).

'The Interrelations of Demographic, Economic and Social Problems in Selected Under-developed Areas'—*Proceedings* of a Round Table at the Milbank Memorial Fund 1953 Annual Conference (New York, 1954).

John Charles Rock, *The Time Has Come* (New York, 1963).

Sir Edward John Russell, *World Population and World Food Supply* (London, 1954).

National Bureau of Economic Research, *Demographic and Economic Change in Developed Countries* (Princeton, 1960).

A. F. Zimmerman, *Overpopulation: A Study of Papal Teachings on the Problem with Special Reference to Japan* (Washington, D.C., 1957).

SECTION FOUR

APPLICATION OF KNOWLEDGE TO HUMAN BEHAVIOUR AND THE DEVELOPMENT OF THE SOCIAL SCIENCES

CHAPTER XVI

THE SCIENTIFIC APPROACH TO HUMAN BEHAVIOUR AND HUMAN RELATIONS

I. INTRODUCTION

At the beginning of the twentieth century the scientific method and attitude so effectively applied by western society to the physical world had scarcely begun to be applied to human behaviour and human relations. There was no body of already tested scientific data on human behaviour which could form the basis for a social technology comparable to the basic knowledge of physics, chemistry and biology from which the greater part of the twentieth-century material technology was derived. During the next fifty years this field became the object of vigorous scientific effort as the social or 'behavioural' sciences were developed and applied.

Although the simple faith in automatic human progress as the fruit of scientific and technological advance lost much of its hold, the first half of the twentieth century was characterized by an unprecedented range of efforts to use positive means to improve human living or to modify human life. Development of the social sciences was greatly stimulated by the search for scientific principles on which to base the social and economic programmes which became essential features of every modern state.[1]

The broad changes that were creating uncertainties, shaking values and making custom an insufficient guide to conduct called forth efforts to find a scientific and not merely an empirical basis for confronting old problems and meeting new ones. The direction of development in the social sciences was dictated not only by scientific curiosity applied to human behaviour and relationships but by the realities of rapid industrialization, mushrooming cities with their crowded slums, migrants and immigrants uprooted from their homes, recurrent economic crises, changing relations between social groups and among peoples, social breakdown reflected in mental illness, delinquency, crime and war.

There was, however, considerable resistance to conceiving of human behaviour as conforming to regularities discoverable by scientific methods, and consequent reluctance to accept as scientific the results of work in these fields. A strong drag of ignorance, inertia and practical difficulty prevented or delayed the use of the best knowledge that became available. Many people felt that man's behaviour was in fact already understood and that the scientific approach could add little or nothing to the vision of the poets, philosophers, religious leaders and elders. Or they insisted that individual variations rather

than statistically recognizable regularities gave richness to life and should receive primary attention. They thought that the complexities of human life and the impossibility of subjecting it to laboratory experiment made it unsuitable for scientific investigation, and they rejected as over-simplifications the hypotheses adopted by social scientists. Some people hesitated to expose cherished attitudes and relationships to objective scrutiny and clung to familiar practices in the face of evidence which discredited their validity.

And even those who looked with greatest confidence upon the scientific study of human behaviour as a means of gaining new insights into mankind's problems recognized that such problems inescapably involve value judgments which are not scientific but rest in the last analysis on a philosophical, moral or cultural base.

In the early years of the century the main centres for the development of the social sciences were in Germany, both in the formulation of social theory and in broad-gauge studies of major social institutions drawn from a wide range of historical and contemporary sources. The Verein für Sozialpolitik offered vigorous leadership, and major writings in economics, sociology and political economy appeared in the many-volumed *Archiv für Sozialwissenschaft und Sozialpolitik*. In France the École Libre des Sciences Politiques was a centre for pioneer studies of political processes. The extensive work in geography carried on in Russia provided the basis for studies of the relation of man to his environment.

After the first world war, growth in these fields was especially extensive in the United States, with emphasis on the application of quantitative methods to the study of human behaviour in various fields—political, economic, social. In the second quarter of the century the social sciences enjoyed greater status in American universities, they were pursued by more people and they received more financial support than they did in Britain and continental Europe, except for history and archaeology which were associated with traditional classical and liberal education. Social science research establishments became numerous in the United States and were well supported by foundation grants or other funds.

Much study in the United States, however, involved the elaboration or experimental testing of theories evolved in Europe or pioneer studies conducted there. The latter included outstanding studies by British anthropologists in the Pacific and Africa, Danish studies of the community impact of local industries, French and Belgian studies of the sociological factors associated with religious observance, and various sociographic studies in the Netherlands, Germany and Austria, to mention only a few. Much work inaugurated in Germany was transferred to the United States with the mass exodus of German scholars during the Nazi régime.[2]

Yet in spite of the vigorous development of research in the social sciences during these years, one can point to few outstanding discoveries which were widely accepted and constituted the basis for further research and theoretical

development. In contrast to the physical and biological sciences, the social sciences did not advance as a common field of study but remained a series of explorations, carried out within the framework of different national outlooks or preoccupations, different schools of thought and different individual assumptions. Although some work was of high quality and wide influence, an account of the social sciences in the twentieth century must be mainly an account of the major areas of systematic research and theoretical analysis rather than of universally accepted findings which modified the general course of knowledge and thought.

At the opening of the century a number of distinct subject and methodological areas were differentiating themselves from older fields of study. Psychology was not wholly detached from its two sources, biological science and philosophy, especially ethics and aesthetics. Sociology was asserting an identity apart from moral and political philosophy. Political science and economics were breaking down the unity of political economy, to focus on their respective areas. Anthropology included aspects that were to remain parts of the field—ethnology, linguistics, folklore and the study of physical types, and Edward B. Tylor (1832–1917) had introduced the concept of culture as the interrelated totality of man's material and non-material heritage that must be recognized as a whole for every society in order to understand the meaning of any specific institutions or techniques. History, which in former times had been written mainly by retired statesmen and churchmen, had become the work of professional historians who developed special methods to deal with the facts or interpretation of the past. Archaeology and pre-history tended more and more to become disciplines of their own, detached from history, although the object of study was the same: man in the past.

By the first quarter of the century each of the above fields had become established as a separate discipline with a specialized body of knowledge and set of theories and with specialized techniques of investigation. But as they extended their scope and refined their methodology they contributed to a growing core of common knowledge and common techniques which were beginning to convert a series of separate fields into something approaching a basic social science. By the middle of the century the principal areas in which knowledge of human behaviour was being developed were:

(1) The psychological processes by which the individual perceives, understands, reasons, judges and reacts; human motivation and human personality; individual differences: These were the areas explored by psychologists, following three principal and distinct approaches: one experimental, using laboratory methods to determine normal psychological processes and the means of detecting individual differences, one observational and statistical to test and study the incidence and interrelationship of differences, the third clinical, using the evidence of patients suffering from pathological conditions

to derive theories of human growth and development which could provide a basis for therapeutic treatment.

(2) The nature of culture, its distinctive forms, mechanisms, dynamic processes and reflection in social structure and individual personality; anthropology, 'the study of man', examined distinct cultures, at first wholly by means of studies of primitive societies, and then also in complex modern settings.

(3) Social structure and social processes, including social institutions, social roles, social stratification and mobility, the source and course of social change, and the operation and interaction of social groups in conflict, accommodation, integration and disintegration: sociologists sought understanding of these phenomena, principally through investigations of modern rather than primitive societies, and they built up a large body of factual evidence related thereto. In contrast to anthropologists, who focused on each unique culture and the totality of interacting factors and made it a matter of method to free themselves as far as possible from preconceptions in order to seek in the data themselves the particular meaning which the studied culture gave them, sociologists sought the basis for general social theory, they selected particular institutions such as the family or class stratification for intensive study, and they formulated a series of concepts and categories in terms of which to accumulate factual data and to analyse social phenomena.

(4) Economic behaviour: the field of economics, embraced factors which affected the operation of the economy as a whole. Economists devoted themselves to theoretical analysis, using hypothetical models and mathematical procedures, and to the accumulation through descriptive studies of a realistic picture of economic institutions and processes.

(5) Political institutions and behaviour: political science as a discipline was concerned with the theory of the state, description of political structures, analysis of political parties and other mechanisms, comparative legal systems and the growth of administrative law, and study of political behaviour. The subject of public administration was developed as a specialized field. In the main, political scientists confined their scope to political institutions, although great corporations, large labour unions and other organizations presented similar problems of structure, function, representation and the exercise of power.

(6) Man's life in the past: historical studies, which had become highly specialized during the nineteenth century in terms of different branches of human life, different periods of the past and different civilizations, nations or regions, expanded in three directions: study of the inexhaustible field of social and cultural history in its broadest sense; intensive investigation of parts of the world other than Europe; and more systematic theoretical exploration of what lies behind historical phenomena. History restricted itself, in line with its method of analysing and interpreting different texts, to those periods for which there were written documents; the past of which no written documents remain became the field of archaeologists and pre-historians who developed

and refined their own methods for interpreting physical remnants that were found by chance, and then for systematically exploring to discover and identify others.

Basic to the development of most of the social sciences was the application of statistical method. Nothing more distinguished the approach to the understanding of human behaviour in this period from that of earlier times than the marshalling and manipulation of quantitative evidence. The use of statistical methods was greatly facilitated by advances in mathematical statistics and the development of calculating and tabulating machines which made possible the rapid analysis of data. For important areas, however, especially those approached by way of anthropology and clinical psychology, statistical techniques though sometimes used were considered inappropriate to determine the unique combination of interacting elements which constituted the subject of study—a culture or a human personality.

Other methods also contributed importantly to social science development. Social surveys of living communities applied refined techniques to the observation and analysis of relationships. Archaeology, brought to a high level of technical proficiency, unlocked great store-houses of knowledge of past societies. Linguistics began to offer a valuable tool for the detection of attitudes and relationships. The study of blood types began to throw light on migrations and interrelations of peoples.

Although each of the social sciences developed its special techniques and brought them to bear on specific aspects of society, there was much interaction among them. Psychology and sociology began to bring together their separate approaches to social psychology as both came to recognize the inseparability of an individual's internal psychological processes from his social experience. The insights into human behaviour and motivation provided by psychology were used by anthropologists, sociologists and political scientists, though rarely by economists, to throw light on the ways in which the cultural setting affects their research and to scrutinize assumptions based on the norms of western society. The sociologists' analyses of social structure and group processes became part of the thinking in political science and were used, especially by British social anthropologists, in the study of primitive societies. Economics remained least affected by the other fields.

Many social problems, moreover, required the collaboration of specialists from several fields. The inter-disciplinary efforts needed to study such problems as juvenile delinquency, urbanism, the economic development of non-industrial countries or population trends had the effect of at least partially reintegrating the social sciences, though rarely could a team of specialists, each with his focus and vocabulary, achieve a degree of integration comparable to that of the individual creative scholar. To some scholars in each of the several fields, the development of a common social theory and method appeared within the range of possibility.

Directions of growth in the social sciences reflected the interests and concern of those who sought to use their results. The development of psychology was stimulated by continual pressure to provide practical tools to educators, doctors, advertisers or administrators and to help individuals to understand themselves, their children and their associates. Anthropology responded to the need to understand people of other cultures and the processes of cultural change, first on the part of colonial administrators and then by international agencies and by people of all sorts exposed to culture contacts and rapid social change. Although sociological theorists sought to understand the structure and functioning of society as a whole, much sociological study was focused on various forms of social breakdown in the effort to understand and cope with such social ills as crime, delinquency, family breakdown, urban slums, poverty and dependency. Economics was forced in new directions by the urgent need of governments to control their national economies during war, to find a way out of economic depression, to try to avoid post-war collapse and to achieve economic development. The tremendous increase in the power and responsibility of the state and the new instruments at its disposal provided a strong stimulus to the field of political science.

Viewed as a whole the social sciences passed through three stages of development in the first half of the twentieth century. The years prior to the first world war were a creative period when the major ideas that were to reorient social analysis were formulated and methods established by such dynamic thinkers as Émile Durkheim, Max Weber, Franz Boas and Sigmund Freud. In the inter-war period social science research was expanded and a large body of empirical studies gave the field a more solid foundation. By the second world war and the post-war years both theoretical and empirical approaches were becoming more closely related with practical application, though the social sciences were a long way from providing scientific bases for action comparable to those offered by the physical sciences.

II. NEW CONCEPTS: BEFORE THE FIRST WORLD WAR

By the opening of the twentieth century the ground for the development of the social sciences had been laid in a number of ways, not only by the comprehensive social theories of such nineteenth-century writers as John Stuart Mill, Auguste Comte and Karl Marx, but by a growing body of concrete materials derived from: the comparative study of law; the work of materialist and positivist philosophers with their emphasis on the study of concrete phenomena as a basis for positive social control; the increasingly full and precise observations of primitive societies recorded by colonial administrators, travellers and missionaries; the rigorous methodology of scientific history emanating from the German universities; and the extension of laboratory methods from biology to psychology. Raw data were being amassed through periodic census enumerations in the countries of western Europe and North

America, and the extensive information thus provided on the populations of these areas was being supplemented by vital statistics and morbidity data which were generally less complete. Statistics of international trade and finance were likewise generally compiled in these areas, and some labour statistics. In some areas under colonial administration, such as Indonesia and India, the collection of census and trade data was beginning to open up the possibility of studying quantitatively some aspects of the life of these regions.

The means were thus at hand for a noteworthy development in response to the aroused social conscience and the tendency to look to science for solutions which characterized these years.

1. *New insight into human behaviour*

The application of scientific method to determining the psychological nature of man first took the form of efforts to test in the laboratory the processes of perception and response to stimuli. The disciples of Wilhelm Wundt (1832–1920) carried to various parts of Europe and America the methods which he had developed in Leipzig in the last half of the nineteenth century for testing such things as an individual's ability to distinguish touch, smell or sound, or to register and recall words or sights.

These methods were based on the principle of isolating and focusing on the specific stimulus and the specific response. They depended heavily upon introspection by the person studied and his ability to report his experience accurately. They were rigorously limited to those stimulus–response reactions which could be produced and recorded under controlled conditions. The physics or physiology laboratory provided the model for the first psychological laboratories.

This approach held the field in the first decade of the twentieth century. It coincided with and helped to reinforce a mechanistic conception of human nature and human society bred of the mechanistic concepts developed in the western world since Descartes and Newton. It assumed that human behaviour could be reduced to a series of physical, chemical, organic or associational responses and that any other assumption was unscientific.

The most famous and far-reaching of the stimulus–response experiments were those conducted by the Russian scientist Ivan Pavlov, beginning in 1901. His brilliant and highly skilled experimental work not only greatly refined the field of physiological psychology at the time, but at mid-century still provided the basis for most of the psychological work in the USSR. Using a dog for his subject, he demonstrated experimentally the process of association, which he described as a conditioned reflex. The reflex was the response which automatically occurred when a familiar stimulus was repeated, in this instance a flow of saliva in response to food. Association meant that something associated with an original stimulus, in this instance a bell rung when the food was produced, could become so identified with that with which it was associated that it would produce the same response in the absence of the latter. The

implications of his findings were obvious for education and other efforts to influence behaviour, as well as for the general problem of communication.

In the early years of the century much attention was directed toward the nature of memory and the process by which the individual learns. Some psychologists, such as E. L. Thorndike (1874–1949) and Robert M. Yerkes (1876–), used animal subjects and observed such processes as how rats learn to cope with a maze. Others used human subjects who were asked to repeat nonsense syllables or numbers. These experiments all assumed that the factors to be studied were discrete, separate phenomena which could be examined in and of themselves, without regard for their context.

The experimental approach called for continual efforts to perfect techniques of observation. Whereas early experimental work had relied heavily on the introspection of the subject, those who sought to give the study of human behaviour the same scientific precision as the study of natural phenomena placed increasing emphasis on ways to observe and interpret overt behaviour. Where animals were used as subjects it was obviously necessary to rely upon observation since the animals could not report their reactions or mental processes. A strong school of experimental psychologists, particularly that led by J. B. Watson (1878–) in the United States, insisted that the only data which had validity for psychological study were those derived from observation of behaviour. Some European psychologists, however, continued to use introspection as a tool of investigation.

The psychologists' attempt to investigate separate mental elements one by one was paralleled by the anthropologists' preoccupation with specific 'culture traits'—items of material culture, myths or kinship forms.

The anthropologists of the late nineteenth century had interpreted the random information about primitive peoples reported by travellers, missionaries, colonial administrators or traders in terms of the concept of evolution, assuming that they were viewing evidence of progressive stages of development from lower to higher cultural forms. Those of the early twentieth century discovered that the heterogeneity of primitive societies defied any neat ordering into a universal formula of stages of cultural development.

Confronted by endlessly varied customs and myths which appeared to be accidental and irrational in their combinations, some retreated from all effort to formulate general theories and concentrated on data-gathering, while others embraced a non-evolutionary interpretation based on the idea of the diffusion of culture traits from one area to another through contact and borrowing. Some of the diffusionists, such as Father Wilhelm Schmidt (1868–1954) in Austria, thought to establish three prehistoric centres of diffusion, or *Kulturkreise*. A British group led by G. Elliot Smith (1871–1937) attempted to trace everything back to a single centre, Egypt. Americans such as A. L. Kroeber (1876–1960) thought that similar traits were invented in many places and that they spread from their various points of origin like ripples from pebbles dropped in a pool. Whatever their theory, most students treated traits as

independent entities whose wanderings could be traced or mapped without regard for either their human carriers or the total cultures of which they were a part.

The influence of Émile Durkheim in France and Franz Boas in the United States cut the ground from under the idea that human society could be understood from the piecemeal study of culture traits. Durkheim, drawing on a wide variety of ethnographic evidence, insisted that an institution must be seen in terms of the function which it performs in its society and cannot be understood out of context; the proper subject of study, he said, is systems, not traits. He held that value systems and ways of thinking are living realities experienced by man in society, that a social perspective is essential to an understanding of all aspects of human behaviour and that it is possible to find objective means to determine the nature of subjective phenomena. He not only exercised a major influence on the concepts and methods of sociology but stimulated work by European cultural historians as well. Boas insisted upon intensive and comprehensive study of the totality of a culture, with attention to the historical process which produced its pattern, the structural interrelationships among its institutions and customs, and the psychological unity which gave these institutions meaning. He initiated a line of anthropological studies with this orientation, especially in the United States.

Although the impact of Durkheim and Boas was not fully felt until the 1920s they laid the basis before the first world war for widespread recognition of the concept that only as the whole is perceived can its parts be understood.

A similar development in psychology, the *Gestalt* theory, dated from the same period though it, too, did not command widespread attention until after the first world war. *Gestalt* psychology was developed in Germany by Max Wertheimer (1880–1943), Wolfgang Köhler (1887–   ) and Kurt Koffka (1886–1941) and spread from there to western Europe, Britain and the United States. It established experimentally, and then applied to many fields, the concept of the structure or whole which determines what is perceived and how. The *Gestalt* psychologists pointed out that more is involved in hearing a melody than merely response to the separate notes, that a person will 'see' the complete outline of a familiar figure when only a few lines are drawn—in short, that what is perceived is a whole, not merely the sum of discrete parts.

This concept not only reoriented much psychological investigation but it profoundly influenced the other social sciences. It set some students of linguistics on the study of meaning and not merely philological forms. It reinforced the anthropologists' use of the concept of culture by indicating a psychological mechanism through which culture could function at the level of each individual. It revolutionized many of the ideas about learning and communication and gave a new impetus and direction to research in both these fields.

On the ancient question of innate versus acquired qualities, the twentieth century inherited religious and philosophical concepts concerning man's moral

nature ranging all the way from original sin to perfectibility, and assumptions as to his original mental equipment ranging from innate ideas to a blank *tabula rasa*. Ideas varied concerning the nature and role of reason. The stimulus-response experimentalists assumed that stimuli came from outside and were responsible for setting in motion the mental processes of the individual. Such a view was challenged by those who insisted that human behaviour reflects inner drives and not merely external stimuli, whether these drives arise from the process of biological adjustment guided by mind as an active agent, as stressed by William James (1842–1910), or from innate instincts, as set forth by William McDougall (1871–1938), or from some kind of emotional impulse. McDougall's concept that human behaviour is purposive received wide acceptance even where his list of specific instincts was questioned or rejected.

McDougall also stressed the social implications of individual behaviour. His book, *Social Psychology*, which appeared in the same year (1908) as the first book by a sociologist on the same topic (E. A. Ross, *Social Psychology*), inaugurated this important field of study, approached from both psychology and sociology.

It was the work of Sigmund Freud during these years, however, which eventually had the greatest repercussions not only within the social sciences but on the public mind. Freud postulated that the individual is born with an unconscious reserve of primitive instincts, the 'id', which strives constantly to influence the developing awareness of self, the 'ego'. His emotional energy is identified with a particular source in the id, the 'libido', assumed to be a fixed quantity in any particular individual. It is derived in the first instance from the impulse to love and to obtain gratification through loving, but may be canalized into varied activities.

On this premise Freud built a theory of the psychosexual development of the child through successive stages: an infantile stage during which the child is preoccupied with his own body and secures gratification in relation to particular parts of it—first at the mouth in sucking, then the bowels in controlling elimination and then the sex organs. As the child becomes aware of another person besides himself, he fixes intense love on the mother, who is the source of gratification or frustration of his desires. He is jealous of whatever competes for the mother's affection, notably the father and, later, brothers and sisters. As he is taught to control his impulses, he experiences intense fear of parental disapproval. In time he incorporates into himself, as his 'superego', the norms to which he learns to conform.

These strains and conflicts which the child experiences through infancy, according to Freud, are so severe that he can only handle them by repressing, or banishing from consciousness, the more unpleasant experiences and the more strongly forbidden desires. By the age of five or six, he has normally thrust his emotional conflicts below the surface where they remain latent, ready to erupt in full force during adolescence. In this latter period emotional

gratification is sought, first with members of the same and then with those of the opposite sex.

The individual who successfully handles the successive stages of emotional development from infancy to adolescence becomes a mature adult. Those who fail to cope with the pressures at one stage or another may have their emotional development arrested at this point, or may repress so much that is intolerable as to create an excessive unconscious drag on the conscious effort to function normally. These are the persons who exhibit immature or pathological personalities or suffer from various types of neuroses and psychoses. It was they who provided Freud with the clinical material out of which he built his theory, and for whom he evolved the method of treatment known as psychoanalysis. In applying this method the psychoanalyst helps the individual to bring up to the surface out of his subconscious the suppressed experiences in order that he may face them, understand their source and be freed from the hidden terror and sense of guilt which the suppressed thoughts and desires have built up within him.

The details of Freud's theory were the subject of lively disagreement and elaboration among his followers but, however supplemented or modified, they showed enormous vitality. Various followers of Freud elaborated his approach in their own way. Alfred Adler (1870–1937) held that the central drive was not for love, as Freud maintained, but for power; he attributed much behaviour to the unconscious sense of inadequacy and insecurity—the 'inferiority complex'—which might lead either to withdrawal or to compensatory aggressive and authoritarian conduct. Carl Jung (1875–) generalized Freud's concept of the libido into an *élan vital* not specifically sexual, and he saw the structure of the human personality as based upon antitheses of thinking and feeling, sensation and intuition, extroversion—predominant interest in objective experience—and introversion—preoccupation with the inner world of thought and fantasy. He thought that as one or the other of these contradictory tendencies dominates the individual's consciousness, the opposite is present in his unconscious. He thus sought to explain both the existence of apparently distinct personality types and their apparently paradoxical behaviour. Later followers called attention to ways in which Freud's interpretations reflected his own cultural environment and might, therefore, lack validity in other cultures, for he drew his theories from observation of the urban middle-class patients who came to his Vienna clinic in the decades before the first world war.

However much the specific content of Freud and his successors' theories were challenged, certain of his concepts were revolutionary in their impact on western thought: that all human behaviour is purposeful, not simply a response to external stimuli, albeit the individual is frequently unaware of what he is seeking to achieve by his conduct; that the processes of infancy and early childhood through which the individual learns to adjust his inner drives to the demands of society are crucial in the formation of his personality and the

determination of his future behaviour; and that the individual, perpetually in a state of tension, resorts to a variety of mechanisms for handling his past experience and the life situations which confront him, including the repression or sublimation of forbidden drives and the reversion to infantile or irrational behaviour when the psychic situation becomes unmanageable or the tensions excessive.

The line of approach to the understanding of human behaviour which Freud and his successors opened up gave direction to a wide range of developments, except in the Soviet Union where his ideas were not accepted. Such developments came first in clinical and then in social and experimental psychology, in anthropology, sociology and political science and in the many applied fields relating to mental health, child rearing, juvenile delinquency, psychosomatic medicine, marriage counselling and even administration, advertising and religion. Coming at a time when the certainties of Newtonian physics had been shaken and the accepted social order in the West was about to be given a body blow by the first world war, Freudian and related concepts released thinking about human behaviour from many of the assumptions by which it had been bound, and provided fresh and dynamic hypotheses in terms of which to observe that behaviour. It focused attention on hidden motives for action and presented in an unfavourable light many attitudes and patterns of approved behaviour, especially, it appeared to many people, the taboos and conventions relating to sex. Although it aroused much fear and revolt among many whose values it threatened, it became an integral component of social thought in the succeeding years.[3, 4]

The other major psychological development of the pre-1914 period, the psychological test, had a pragmatic origin and application. Its purpose was to detect differences among individuals, initially in what was termed 'intelligence', or the ability to acquire knowledge. The tests rested on the theoretical assumption that there are innate qualities which can be tested, i.e. that the human organism is not wholly the product of the stimuli to which it is exposed. Beyond this basic assumption, the makers of tests followed the pragmatic procedure of looking for norms in the observed responses of the group rather than in any concept of normal development. The norm for a ten-year-old child was what most ten-year-olds were found to be able to do; the child of that age who could not do this was rated as below the average or norm; the one who could do what most ten-year-olds could not do was above this norm.

The tests, designed originally by Alfred Binet (1857–1911) and Thomas Simon (1873–   ) in France in 1908 and revised by Lewis M. Terman (1877–1956) in the United States in 1916, contained exercises which were found effective in sorting out the children of the groups used to build the tests, and they were scored so that the total result placed the tested child below or above the normal mark of 100. On the assumption that the 'intelligence' which was being tested was a permanent characteristic of the individual, the child

should come out with the same I.Q. (intelligence quotient) if he were retested at a later age.

The first objective of such tests was to enable educators to identify children who were so subnormal that they could not profit from ordinary instruction, and in general to help teachers to appraise the capacity of their pupils. In the places where they were originally designed and among groups with comparable experience they served this purpose sufficiently well, so that they came to be widely used. In the course of time, however, it became apparent that the social experience of the individual could markedly affect his score, and that the tests were not valid instruments for comparing persons whose experience differed because of nationality, region, urban versus rural background, class or other social distinction. The content of the tests devised during the first part of the century strongly reflected the urban, middle-class culture of certain segments of western society.

Moreover, as the intelligence tests were used on a variety of subjects it became apparent that they depended heavily on the verbal facility of the person tested. Since they were designed to reflect generalized mental capacity and not merely verbal facility, this discovery led to the formulation of a variety of non-verbal tests, designed to avoid the distortion of verbalism and, hopefully, to provide tests less dependent on the individual's social experience. It came to be recognized also that the score achieved on any type of test which probed for innate capacity might be affected by the subject's emotional state and his reaction to the circumstances in which the test was given.

While the first tests were strictly for children, the possibility of testing individual differences appealed to those who had to evaluate the capacities of adults, and during the first world war such tests were used to sort out military recruits for work or training assignments. Thereafter a substantial proportion of psychologists devoted their efforts to designing and administering tests of a wide range of aptitudes and characteristics, in the hope that standard tests could be devised which would detect human qualities much as the tests evolved by natural scientists could determine properties of materials.

2. *Social processes and structures*

In the years before the first world war there were no developments of the other social sciences which had the far-reaching influence of those in psychology and anthropology. Sociological theory was elaborated, not only by Dürkheim but by a number of thinkers, particularly in Germany and Italy, who moved away from the dominant nineteenth-century theories contained in the positivism of Auguste Comte and the evolutionary social theory of Herbert Spencer, and who brought the assumptions of nineteenth-century western society under scrutiny. Among these Max Weber (1864–1920), in his comprehensive analysis of economics, politics, religion and the interrelations among institutions, insisted that a knowledge of the meaning of any activity was a prerequisite to establishing causal relationships and he stressed the role of

values in moulding social behaviour, as for example in his thesis that the Protestant ethic, by its sanction of thrift and identification of spiritual salvation with economic success, provided the spirit of capitalism and thus was responsible for the latter's growth. Vilfredo Pareto (1847–1923) developed a cyclical theory of social change based on the alternation of strong leaders committed to positive ideals and cunning opportunists skilled in manipulation.

Techniques for the systematic observation of social life, however, were slow to be applied. Even the founders of American sociology, which later became heavily empirical, insisted on rigorous logic but not on rigorous observation. The new efforts to apply theory to practice or to test it by observation were mostly limited to problems of social breakdown such as those encountered in the field of penology, and to the social surveys which were undertaken to determine the need for local social services.

Some of the most significant developments in techniques of research during these years came in archaeology. Scientific methods of digging based on engineering principles, developed by A. H. Pitt-Rivers (1827–1900) in the late nineteenth century, were adapted by Flinders Petrie (1853–1942) to excavations in Egypt during the early years of the twentieth century, and further elaborated with the aid of a multiplicity of technical devices. These methods enabled the archaeologist to recover from artifacts of all sorts a picture of a past age, including something of its culture, the characteristics of its people and its social history.

Archaeological research brought to light during these years the ancient civilizations of Egypt and Mesopotamia, Crete and Asia Minor, of India, China and Indo-China, of the Maya in Central America and the Inca in Peru. Other techniques moved the frontiers of pre-history into an ever more remote past. It was not until the middle of the century, however, that new knowledge of radioactivity made it possible to date organic materials such as wood or grain brought to light through excavation and revealed that many evidences of early societies were older than had been assumed. This tremendous expansion of knowledge of past human societies was a prime factor in shaking many traditional concepts and in providing perspective on human development and on the rich diversity of human cultures.

A growing number of historians, too, were expanding the knowledge of the past by carrying their studies beyond the national history, mostly political and diplomatic, which had been the main interest of nineteenth-century historians, shifting their interest to economic history and then to various social or cultural aspects. Within each of these fields specializations developed around the history of agriculture, finance or business, of social orders and classes, of such institutions as law, religion or warfare. Each of these specialized fields, and others such as the history of literature and the arts, of technology and of science, developed its own methods and techniques to handle its own problems. Although historians thus became highly specialized in relation to

period and area as well as subject-matter, they brought to light an ever-widening body of evidence on the life of the past.

The scope of historical study was further extended to include parts of the world to which critical historical scholarship had not been applied. Western scholars had been preoccupied with the history of western areas, while Asian countries had generally lacked a tradition of historical scholarship. As European scholars brought critical historical research as well as archaeological exploration to bear on Asian areas, they enabled these countries to reconstruct their past and develop an historically-based self-image, and they stimulated Asian scholars to develop and apply critical historical techniques themselves.

Political science emerged as an area for systematic study with its main content divided between description of political structures and theoretical discussion of political philosophy; techniques of administration and practical politics were learned on the job. Critical study of political processes and political structures was stimulated by evidences of malfunctioning such as revelations of graft and corruption in American municipal administration and the difficulty experienced by some continental European countries in their efforts to operate parliamentary systems. The pioneer work of André Siegfried, *Tableau politique de la France de l'ouest sous la troisième république* (1913) opened up the study of political attitudes. Marxist political thought was challenging liberalism and its influence was reflected in the prominence of socialists among European political scholars. Writers in several countries began to call attention to irrational elements in political behaviour. Social causes rather than moral or hereditary weakness were increasingly recognized as responsible for poverty and crime. But it was not until the 1920s and 1930s that systematic study was directed to the implications for political behaviour of newly developed understandings of motivation and social structure, or to political and administrative processes.

In spite of the fact that economic behaviour had long been the object of systematic theory and that the impact of technology was most direct in this area of living, the field of economics remained predominantly theoretical well into the twentieth century. Classical *laissez-faire* theory remained dominant, subject to efforts toward greater mathematical precision. According to this theory, 'economic man' was assumed to act rationally, in quest of profits if he was an entrepreneur and to avoid starvation if he was a worker. With this motivation, with legal instruments which assured the security of property rights, and with flexible prices in a free market, the economic system would operate automatically. It was believed to be fundamentally stable, for, according to 'Say's law', there could be no prolonged unemployment. The system was presumed to be progressive, for the quest for profits would lead inevitably to the improvement of product, lowering of price and a rising standard of living.

The whole economic structure and rationale was challenged fundamentally by the followers of Karl Marx, who maintained that, far from providing a

stable equilibrium and progressively higher standards of life, the system inevitably would produce progressive poverty for the masses, insufficient markets for the products of industry, sharper and deeper depressions and ultimately collapse and revolution. In the years before the first world war however, and even up to 1930, there appeared to be enough face-value evidence to sustain the general assumptions of stability, progress and capacity for economic recovery and outside the Soviet Union the Marxist challenge did not deflect the main stream of economic thought.

Nevertheless, the Marxist hypothesis concerning the relation between forms of production and the whole range of social institutions in any society had a profound impact on many who did not become doctrinaire Marxists—sociologists, political scientists and historians as well as economists. Especially in Germany, Sweden and elsewhere in continental Europe, it acted as a stimulus to studies of concrete phenomena such as housing, taxation or tariffs, as well as labour, class structure and political behaviour.

Other attempts to test economic hypotheses by systematic observation took the form of broad historical studies by German scholars who undertook to derive laws of economic development from the comparative study of economic systems, and original work by a few students, such as Thorstein Veblen (1857–1929) in the United States, who scrutinized the characteristics and operation of specific economic institutions. Meantime, possibilities for more accurate and scientific study of economic behaviour were being created as data on a variety of subjects not heretofore recorded were systematically collected and published by governments and other bodies.

Prior to the first world war most of the serious study and analysis of human behaviour was conducted within the framework of western society and on the assumptions of the cultural norms of that society. There were outstanding exceptions, as in the work of Max Weber who studied the relation of religion to economic ethics and social life in Hinduism, Buddhism, Confucianism, Taoism and ancient Judaism in an effort to understand this relationship in Christian societies of the West. But rarely did anyone assume that civilized man might have something to learn from his primitive cousins, or that the study of primitive societies might affect the understanding of his own.

III. NEW METHODS AND MATERIALS: THE INTER-WAR YEARS

In the 1920s and 1930s the major disrupting events which destroyed the nineteenth- and early twentieth-century complacencies—war, revolution, depression and the challenge to western supremacy—created a milieu in which it began to appear as important to understand social behaviour as to determine the causes of disease. Anthropological studies, especially in the United States and Britain, began to challenge rather than, by assumption, to confirm prevailing concepts of human behaviour. Together with new concepts derived from *Gestalt* and Freudian psychology, they provided new tools of obser-

vation and analysis. At the same time concrete studies of social, political and economic behaviour and structure, conducted with the aid of new statistical techniques, provided a growing body of data for social study.

1. *New perspectives on culture*

Although Franz Boas had insisted as early as 1901 that the mind of primitive man was not different from or inferior to that of civilized man but that the same mental processes were merely applied to different conceptions of reality and to different experience, it was not until the 1920s that his findings received full attention and their implications were fully recognized. Influential scholars who maintained that primitive man was unable to think rationally, such as Lucien Lévy-Bruhl (1857–1939), continued to be widely read, especially in Europe.

By the 1920s the principle of cultural diversity as against cultural superiority was well established on the basis of field studies of living communities covering all aspects of their social life. Thenceforward the major anthropological effort was directed toward studies of total societies in a systematic attempt to discover their social structure or cultural configuration.

This work resulted in a large number of ethnographies of primitive societies, outstanding among which were those of Bronislaw Malinowski (1884–1942) (*Argonauts of the Western Pacific*, 1922) and A. R. Radcliffe-Brown (1881–1955) (*The Andaman Islanders*, 1922) and their followers in Britain, of Franz Boas and his disciples studying Indian tribes in the United States and in the South Seas, of Alfonso Caso (1896–) and his associates in Mexico, of Nicolaus Adriani (1865–1925), Albertus Kryut (1869–1949) and other Dutch scholars in Indonesia, of Russian ethnographers both before 1917 and under the Soviet régime, and of French scholars in Africa, Oceania and Latin America.

British scholars, such as Raymond Firth (1901–), Meyer Fortes (1906–) and others, calling themselves social anthropologists, generally focused on systems of kinship and other institutions which gave social, political and legal structure to primitive societies, and examined them in terms of the social functions which they performed and the social integration which they provided. They hoped that by thus limiting the field they might develop sharper concepts and more scientifically established general hypotheses than if they followed what they regarded as the 'grab-all' method of looking indiscriminately at all aspects of a culture.

Many American scholars, on the other hand, such as Edward Sapir (1884–1939), Ruth Benedict (1887–1948) and Margaret Mead (1901–), undertook to explore the psychological content of particular cultural integrations. Ruth Benedict's *Patterns of Culture* (1934) focused attention on the concept of culture as something more than an accumulation of customs—as the particular dynamic interrelation among the beliefs and practices of a society into which each new member is inducted and by which his behaviour and his personality

are moulded. Margaret Mead's classic study, *Coming of Age in Samoa* (1928), undertaken to test how far the psychological phenomena of adolescence observed in western society are specific to western culture and how far they are universal phenomena, was one of a series of studies which tried to determine the limits within which cultural influences were effective and the method of their transmission.

Anthropological field studies which introduced people to ways of life of primitive communities provided a perspective on western society and had an effect on thought and attitudes far beyond this field of knowledge. The studies of child rearing and child development in the South Seas not only showed that the norms of western society did not hold universally, but indicated that some of the problems of child development which were recognized in western society were absent in the societies studied and thus called into question the former's standards and processes.

The concept of culture entered into the thinking of other social scientists and of the lay public. Comparative studies were undertaken of children in different cultures, and efforts were made by psychologists and anthropologists to develop tests or techniques of observation which would permit the study of common problems or characteristics across cultural lines. The psychiatrist, Dr Karen Horney (1885-), in *The Neurotic Personality of Our Time* (1937) insisted that the neuroses with which the psychiatrist deals are not independent of the individual's cultural milieu but are often precipitated by its pressures and expressed in its terms, and are susceptible of treatment only in relation to the culture which has shaped the individual's personality and has given him his system of values.

Social workers dealing with immigrants and rural–urban migrants became aware that they were confronted with cultural differences and consciously tried to avoid the tendency to judge their clients by the standards of the group to which they themselves belonged. Colonial administrators were increasingly conscious of their need to understand the cultural values of their subject peoples. Even an agency such as the United States Department of Agriculture, traditionally dedicated to technical improvements in crops and livestock, launched a series of cultural studies of distinct agricultural communities and attempted to develop a culture-area map of rural United States in order that its programmes of technical aid to farmers and agricultural improvement might be adjusted to the cultural differences among rural regions of the country.

The impact of anthropological studies was perhaps greatest in respect to the question of race difference. Throughout human history assumptions of racial superiority have reflected the ethnocentrism of virtually every society and power group, to whom the 'others' have been 'barbarians', 'natural slaves' or 'lesser breeds without the law'. At the opening of the twentieth century this universal tendency took the form of the concept of the 'white man's burden' associated with the political and technological supremacy of European peoples, and backed by the evolutionary concept of the survival or emergence of the

superior race. While the white man who regarded himself as superior had to acknowledge the cultural richness of the ancient civilizations of China and India, and the obvious evidence of superior capacity on the part of the Asian Japanese to master and use the white man's technology, the white administrator, business man, tourist and missionary moved through his colonial dominions and spheres of influence with a sense not only of power but of racial superiority. To the colonial subject the white man's authority was often less offensive than his unconscious contempt.

The physical anthropologists at the beginning of the century, accepting the prevailing assumptions, investigated the relationship between physical characteristics and mental or personality traits. They found, however, that no relationship could be established between superior or inferior capacities and racial characteristics. On the other hand the evidence as to the differentiating effect of culture was clear and positive. Most anthropologists had concluded before 1920 that the concept of race as a determinant of the capacities of individuals or peoples had been discredited by the evidence.

In the 1920s their findings influenced the psychologists, some of whom had formerly given a racial interpretation to comparative scores on psychological tests. Tests given to American army personnel for the purpose of work assignment, for instance, had at first been seized upon as evidence of different capacities among groups with different racial and nationality backgrounds. Closer study of the results, however, had revealed that test scores were strongly affected by the individual's social and cultural experience; it was observed, for example, that average scores for Negroes from urban centres surpassed those of whites from some rural areas. By the time of the Nazi rise to power the racial theories upon which National Socialism rested were already at variance with scientific opinion throughout the world.

It required the changed power relationships among peoples, brought to a head by the second world war and the subsequent collapse of colonialism, fully to discredit assumptions of racial superiority. But the scientific denial of racial inequality worked as a leaven undermining the *status quo*, both between peoples and within racially heterogeneous populations in various parts of the world.

2. *Impact of Freudian and* Gestalt *psychology*

Comparable in pervasiveness and influence to the concepts derived from the study of primitive peoples were those derived from Freudian and *Gestalt* psychology. Clinical practice using psychoanalytical techniques provided a growing body of material, drawn from deeper levels of consciousness and the unconscious, with which to test the hypotheses of Freud and his followers as to the processes of human development. The wholesale emigration of scholars and professional men from Germany and Austria where these ideas and methods had originated and flourished gave a great impetus to their spread, especially in the United States.

In the effort to develop means to penetrate into the private world within

which the individual lives and to discover the structure of his personality, clinical psychologists developed a series of projective tests, of which the most famous were the Rohrschach test devised in Switzerland and the thematic apperception test (TAT) devised in the United States.

From the work of psychologists and anthropologists there emerged the concept of 'personality' as the particular dynamic integration which each individual makes of his experience. This concept, broader, deeper and more comprehensive than the more limited concepts such as perception or consciousness with which psychologists had originally worked, became the focal idea for much of the work in the succeeding years.

The most dramatic general impact of Freud's thinking was to give a basis in scientific theory for the release of the subject of sex from the taboo on discussion under which it had been placed in western societies by the code of nineteenth-century morality. Although Freud's emphasis on the importance of the sexual drive in human development was only a part of his total system, it was this which focused public attention. While many other factors contributed to the change in sex *mores* in the years after the first world war, including changes in the position of women, weakening of religious sanctions and the revolt against traditional values, the rationale which Freud offered supported a freer attitude toward sex and provided a new set of terms in which to study and discuss it.

By the 1940s the subject of sex had become a field for systematic investigation with the application of social science research techniques. Going beyond the theoretical analysis of Freud and his followers and the popular works of Havelock Ellis (1859–1939), Alfred C. Kinsey (1894–1956) undertook to determine the actual practices of a statistically selected sample of men drawn from a cross-section of American society, and he followed it with a similar study of women. The results of these studies were widely read and discussed, and they brought into question many of the assumptions of conventional morality.

In the course of time Freudian concepts were applied to the growing fields of child study and juvenile delinquency. Research centres where studies were conducted on the development and behaviour of the very young child and child guidance clinics for children with emotional or behaviour problems both expanded rapidly during the 1920s. Initially the problems studied in these centres were defined pragmatically, but as the influence of Freudian ideas grew, both the child study and child guidance centres began to look at their material in Freudian terms. By the late 1930s evidence from these sources as well as from the clinics of practising psychiatrists and the experience of social workers was being used to test and refine Freud's hypotheses. All these sources tended to confirm the assumption that the earliest relationships which the infant establishes with a maternal figure are a vital factor in his personality formation and his relation to the world.

In the USSR, where Freudian thought was not accepted, corresponding

studies were carried on in pedagogical institutes on hypotheses derived from the physiological and psychological studies of Pavlov and his followers and the application of Marxist-Leninist principles.

Freudian theory also focused attention on the problem of motivation. His concept of basic drives and the individual's need to handle feelings of fear, hate and guilt in the process of canalizing them into socially acceptable forms, provided a basis for interpreting actions whose purpose the individual himself often did not recognize. The concept that much behaviour is unconsciously purposeful was of practical importance to those who wished to influence action, and it offered a new tool with which to study various types of behaviour. It also was used to support tendencies toward irrationalism and anti-intellectualism.

Political behaviour was one of the areas to which the growing knowledge of motivation and the various techniques of social observation were applied. Especially in the United States, political scientists looked for evidence of the motivation which gave political leaders their drive for power, and tried to examine the corresponding motivations which led people to follow leadership of a particular type. Carrying further the approach to political realities initiated at the École Libre des Sciences Politiques, Charles Merriam (1874–1953) and his associates at the University of Chicago brought under scientific scrutiny the nature and structure of political parties, their formation and control, the basis of their hold on their members and their relation to the legislative and executive machinery of government. Harold Lasswell's (1902–) *Psychopathology and Politics* (1930) introduced psychoanalytic concepts into the study of political behaviour and deepened the study of political leadership. Voting behaviour was analysed statistically in the effort to determine what factors appeared to influence people to support a candidate or a party or not to vote at all.

Much effort was dedicated to the study of public opinion. Public opinion polls were conducted systematically, using refined sampling techniques to permit a determination of the views of large numbers from small scientifically selected groups. Studies were undertaken into the formation of public opinion and its modification, the spread of and resistance to propaganda, the question of whose opinion actually functions as 'public opinion', and the manner in which opinion actually affects political behaviour.

The processes of administration were subjected to systematic analysis in the effort to evolve general principles that could guide the multiplicity of new and expanded agencies set up to carry out the new functions which governments everywhere were taking on. Utilizing not only political concepts of structure and authority but concepts relating to motivation, communication and group interaction drawn from other fields, specialists sought a basis for converting administration from a personal art to a systematic set of standard processes and relationships, and established research and training centres through which to impart this approach. Yet in spite of extensive study, insight into political

behaviour and political processes in varying circumstances remained superficial and limited.

When in the 1930s events in Nazi Germany revealed highly irrational political behaviour in what had been thought to be a predominantly rational society, attention was directed to the possible effect which the structure of the family and the early experience of the child might have on the kind of political behaviour that can be expected of adults. The concept of the 'authoritarian personality' was evolved and studied, and psychologists and political scientists joined to explore the question of whether such a personality could be expected to operate democratic institutions successfully. Some psychologists such as Erich Fromm (1900–) (*Escape from Freedom*, 1941) raised the further question as to whether free institutions place demands on individuals that are beyond their capacities and desires, and they thus forced political scientists to review their fundamental assumptions.

Economic conduct was the only major aspect of human behaviour not subjected to systematic scrutiny in the 1920s and 1930s in terms of the new understanding of human motivation and the concept of culture. Thorstein Veblen in the United States had attempted to introduce a recognition of various motivations into economic thinking, pointing to some of the motives affecting patterns of consumption (*Theory of the Leisure Class*, 1899) and to the conflict in motivation between the technician and the businessman (*The Engineers and the Price System*, 1921). The widely used Hawthorne studies of productivity* brought out the effect on a worker's output of his emotional state and personal concerns. But even the institutionalists who attempted to build up a descriptive picture of the actual operation of economic institutions gave little attention to the human element. The great majority of economists continued to base their theoretical analyses of the economic system on the assumption that man is governed by rational choice, although they were well aware that this did not accord with the new knowledge.

3. *Scrutiny of social institutions*

At the same time that new psychological insights and studies of primitive societies were enlarging the knowledge and understanding of human behaviour, several aspects of western social structure were being subjected to realistic description and analyses. In the 1920s and after, sociological studies based on direct observation greatly increased. A series of ecological studies of urban communities, most notably those conducted at the University of Chicago following the lead of Robert E. Park (1864–1944), delineated patterns of urban growth in relation to areas characterized by social breakdown. Demographic studies of census data and vital statistics revealed some of the dynamics of population changes.

Total communities were studied for evidence of social structure and social processes, and efforts were made to document the processes of social change.

* See Chapter IX, p. 278.

The community study, which had been developed before the first world war as a simple social survey for planning welfare services, became a more refined tool for testing sociological hypotheses with respect to such questions as the structure and functioning of social class, the nature of social groups, the character of social institutions, the performance of social roles and the operation of social controls.

As agricultural agencies came increasingly to recognize the importance of social factors in the improvement and use of agricultural technology, rural sociology became an important field of study in countries of advanced agriculture. In eastern Europe studies of rural life in the 1930s were closely related to political movements for social reform on behalf of the peasantry. Problems of Hungarian villages were brought to light by the studies of a group of young writers who called themselves the 'March Front'. Research by students of sociology at the University of Bucharest led in the late 1930s to a short-lived programme requiring students completing their university or high school courses to work in villages and study peasant life for a year. Detailed studies of peasant life were also undertaken in Yugoslavia.

Immigrants and migrants provided evidence on some of the processes of acculturation, as in the major study by W. I. Thomas and Florian Znaniecki of *The Polish Peasant in Europe and America* (1918). A variety of other social groups were studied for details of social stratification and factors affecting social mobility. Anthropologists, too, began to apply the methods and concepts derived from their studies of primitive peoples to the scrutiny of non-primitive societies. This body of sociological and anthropological research brought considerable sophistication to thinking about the nature and problems of modern social life, although, as noted at the fourth World Sociological Congress in 1959, many sociologists tended to avoid broad generalizations and focused on the specific situations which they were studying.

The nature of economic institutions was also becoming increasingly familiar through a growing body of descriptive studies. Some of these showed that assumptions basic to economic theory did not accord with contemporary conditions. In the large and increasingly dominant corporation, ownership was found to be so divorced from control that the traditional concept of economic motive power, the private owner pursuing individual profit, did not hold. A high degree of price rigidity, rather than the price flexibility which in theory provided the mechanism for economic adjustment, was found to exist, apparently associated with the concentration of production in relatively few hands. A new group, the managers and other executives of business corporations, was seen to be emerging as the locus of much economic power. Some people saw them as a new 'class' and spoke of their rising power as a 'managerial revolution' (James Burnham, *The Managerial Revolution*, 1941). Marxists on the other hand insisted that in spite of the changes in capitalist society its nature and essence remained the same.

A body of knowledge was also being developed with respect to dynamic

economic processes. Studies of national income—its total, its sources and its distribution—were undertaken in the major industrial countries in the 1920s and thereafter were kept current and made more comparable. Studies of consumer expenditure provided a basis for recording changes in the cost of living and for comparing patterns of spending at different income levels. Studies of economic interrelationships and growth produced formulae for estimating fluctuations in the demand for specific products under conditions of higher or lower national income, and the levels which would be required to maintain full employment.

Classical economic theory was further developed, chiefly in the work of Joan Robinson (1903–) in Britain and Edward Chamberlain (1899–) in the United States in respect to competition among the few, but in fundamentals it remained unchanged. Neither the studies of economic institutions nor those of dynamic economic relationships were incorporated into the theoretical structure. Nevertheless these studies provided a body of knowledge and techniques which could be drawn upon when the combination of economic disaster and fresh theory brought a reorientation of economic thought.

The world-wide economic collapse and depression of the 1930's shattered confidence in traditional *laissez-faire* economic theory. As a body, economists failed to predict the crash of 1929.[5] As crash lengthened into depression and unemployment spread, confidence that prosperity must be just around the corner in an automatically adjusting economy gave way to a determination to take a fresh look at the facts of economic life. Some found a ready answer in the Marxian analysis. More, unwilling to accept the idea that the free enterprise system was a complete failure and doubtful that even the evidence of the depression fully sustained Marx's hypotheses, looked further.

Major stimulus to the reorientation of economic thinking came from the Englishman, John Maynard Keynes (1883–1946). His challenging *Economic Consequences of the Peace* (1919) had arrested the attention of economists at the close of the first world war but it was his *General Theory of Employment, Interest and Money*, published in 1936, which focused thinking and offered a basis for policy.

Without departing from the two major premises of classical economic theory, price flexibility and market competition, Keynes maintained that the system was not necessarily self-correcting, and that equilibrium was possible at less than full employment—as the years of depression seemed to make fully evident. He held that the place to look for the disturbing factor was not in the behaviour of production, prices or interest rates, but in what was happening to consumption and to the balance between consumption and saving. He even offered a remedy—adjust the government's spending in relation to taxes so as to increase consumption when demand is insufficient to take off the market the goods produced.

While Keynes' theories were by no means universally accepted and led to

lively and continuing controversy among professional economists, they helped to deal the *coup-de-grâce* to *laissez-faire* economics. Thus stimulated, economists and statesmen of the industrialized countries set out in search of possible controls which might be used to keep their economies functioning and growing and their people employed.[6]

All these tendencies, as well as the changed outlook of the natural sciences, were reflected in the study of history, enlarging its scope, modifying its methods and providing the historian with concepts which he could apply to the societies of the past. Historical students, especially those concerned with the modern period, began to make more use of the concepts and research techniques of the related social sciences and they could count on more systematic documentation with which to work. An ever growing body of statistical data made it possible to reconstruct in quantitative terms what might be only hinted by literary sources; archives were better organized and records more systematically deposited with a view to providing a basis for historical study, as in the war-documentation collections assembled and made available for research by governments in several countries.

In reaction against the specialization which broke up the undivided continuum of history into fragments, a number of historians developed cultural history as a field. Their concept of 'culture' was not the limited study of customs and usages which had constituted the nineteenth-century historian's version, but rather the comprehensive concept used by the anthropologist. The leading Belgian historian Henri Pirenne (1862–1935) tried to present in his *Histoire de Belgique* (7 vols., 1910–32) the political, economic, social and intellectual history of his country as one integral whole. The American historians Carl Becker (1873–1945) and Charles A. Beard (1874–1948) were part of a similar movement to develop a 'new history'.

Historians who sought to apply this new approach had to deal with complicated interrelations between the different fields of human activity—political, economic, social, intellectual, religious. In calling for an expanded view both in scope and geographical extent, the new history or cultural history thus placed heavy demands on the historian for, in addition to the interrelation among fields of activity, the interaction among civilizations became an inescapable part of his study. This required the European or American historian to have knowledge of Asian history and vice versa.

In contrast to the nineteenth-century historians who had taken for granted the values of their societies and, like their counterparts in the natural sciences, had concentrated on achieving scientific objectivity, a growing number of historians began to question the assumptions in terms of which they were viewing the past. Several German historians sought terms in which to evaluate whole periods of civilizations. In the footsteps of the Swiss historian, Jakob Burckhardt (1818–97), Karl Lamprecht (1856–1915) vehemently insisted on studying societies as cultural wholes and tried to characterize entire periods in psychological terms. Oswald Spengler (1880–1936) saw civilizations as inde-

pendent organisms passing through cycles, and he identified the contemporary cycle of western civilization as a period of decline. The English historian Arnold J. Toynbee (1889–), making a somewhat similar assumption of a cyclical process, looked for causal factors which produced the dynamic and waning periods of great civilizations.

In general the concept of 'law', regularity and repetition was still a point of discussion among historians at mid-century. On the one hand there were many historians who rejected the existence of historical laws with the argument that historical phenomena differ essentially from both natural and sociological phenomena in that they are 'one-time events', as German thinkers at the turn of the century such as Heinrich Rickert (1863–1936), Georg Simmel (1858–1918) and Wilhelm Dilthey (1833–1911) phrased it. On the other hand there were those historians who either accepted the idea of historical laws or did not reject the idea in advance. These ranged from the orthodox Marxists, who pursued evidence to show that Marx had already found the correct societal laws, to scholars like Spengler and Toynbee who formulated their own historical laws. They included historians of various views, many with a more or less Marxian outlook, who neither accepted a predetermined system of laws nor designed their own but sought to place historical phenomena in some broad pattern of societal regularities.

These different opinions about the structure of history and the best way to analyse it brought the need for a special study of such problems as periods and rhythms in history, and the part played by the great individual on the one hand and the masses on the other. This field of study came to be known as theoretical history or as theory of history and it largely replaced what was formerly called philosophy of history, substituting theoretical analysis on the basis of the historical phenomena themselves for speculation about history on the basis of a *Weltanschauung*.

But however greatly historians differed in their opinions and formulations, the most eminent among them turned away from the extreme specialization that threatened to separate history from life. One of the first to do this was the French historian Henri Berr (1863–1954), who in 1900 founded his review *Synthèse de l'histoire* and tried to work out a synthetic view in the hundred volumes of *L'Évolution de l'humanité* of which he was for years the indefatigable editor. This work may be regarded as one of the first efforts to write what can properly be called world history.

Indeed, the writing of world history became possible only in the twentieth century, for the interrelations of regional histories came to be understood very much better during this period. The excavations at Arikamedu, for example, disclosed how close was the connection between the Roman empire and southern India in the first and second centuries AD. In the same manner the excavations in the deserts of central Asia showed the close relations of developments in India and China. Disclosure of the intimate contacts between the Hellenistic world and Asia through the silk route to China and through

Bactria to India told the same tale. In fact the historical work in the twentieth century showed regional developments to have been so interrelated at various periods as to leave no place for completely isolated regional history in any part of Asia or Europe. Interest in Africa's past was also aroused and work in this field was dispelling the idea that Africa had no history and was beginning to bring the history of that region into relation with that of other areas. The attention of historians was drawn to all these interrelationships of the past as the same parts of the world again became interrelated in the modern period.

4. *Social science in the Soviet Union*

The developments described above took place, in the main, outside the Soviet Union. Within the Soviet system social science took a different course, following three main lines. Ethnographic studies continued until the late 1920s to be linked to geography as they had been in the nineteenth century, and after the development of ethnology as a separate field they continued to explore the varied peoples of the Soviet Union in terms of human geography —man in relation to his environment and the origins and movements of peoples in relation to the characteristics of regions and areas. Soviet psychology rested squarely on the work of Ivan Pavlov, and thus on a physiological base. With some variation in emphasis through the years, it followed a continuous line of experimentation into the physical bases of behaviour and ways by which it may be conditioned. The general fields of history, economics and political science were pursued as an elaboration and application of Marxian principles. Phenomena were examined to find in them the dialectic relationships assumed to exist and to identify the historical materialist process. In this view economic history embraced much of what fell within other social science disciplines elsewhere. Soviet students rejected most sociology and cultural and social anthropology as being bourgeois, introducing false or irrelevant problems and assumptions, and in some cases having a 'racist' or a wrong political orientation.

Soviet social science was more directly focused on tasks of social engineering than was that of western Europe and America. Since the nation was engaged in a vast undertaking for conscious and directed social change, the social sciences were expected to yield instruments which could be used toward this end. Both natural and human geography provided knowledge essential to the development of the Russian land mass and the integration of its varied nationalities, while economic geography contributed directly to economic planning. Psychological studies had their direct value to education and to propaganda. The very extensive research and training in pedagogy applied Pavlovian psychology; the ideas of Freud and, except for a brief period in the 1920s, those of John Dewey and others who were influential in learning theory and education in other countries, were rejected as making bourgeois assumptions and applying bourgeois values. Training in social

science was part of the preparation of Communist party workers for the development and use of propaganda.

The main fields of application were the many problems of economic organization and social direction which confronted Soviet planners and technicians. Much work was intensely practical for it was directed toward the solution of problems of planning, the operation of enterprises and the administration of agencies under the changing conditions of a socialist economy and communist state. At a more theoretical level it proceeded on the assumption that an historical materialistic process is at work and if it can be accurately detected it will be possible to line up forces effectively in its support. Even where dialectic relationships are not immediately evident, further study will be bound to reveal them. Marxist principles thus provided a common framework and set of analytical tools to all work in the field and a unified basis for interpreting and integrating results.

IV. NEW APPLICATIONS: DURING AND AFTER THE SECOND WORLD WAR

The second world war and the post-war problems of reconstruction and development gave a tremendous impetus to the expansion of the social sciences, first by calling for their application to pressing problems and then by making available funds and stimulus for work in many directions. Social scientists of all sorts were called upon to place their knowledge at the service of their respective countries for the conduct of war and the achievement of reconstruction and, in the years after the war, for international co-operation.

1. *Stimulus to applied research*

Much more elaborate devices for the testing of aptitudes than had been employed in the first world war were applied to the screening of military personnel and their assignment to proper functions; tests for the analysis of personality were also used. Psychological and psychiatric techniques were utilized for the assessment of morale and in the rehabilitation of neuro-psychiatric casualties. For the conduct of psychological warfare all sides enlisted their most skilled personnel in the task of undermining their opponents' will to fight and sustaining the spirit and motivation of their own people and their allies. Anthropologists were called on to analyse the culture of opponents and to recommend ways of dealing with them. The terms upon which hostilities were ended in the Pacific were reported to have been based on an anthropological evaluation of cultural factors, as well as military analyses of the strategic situation. In order to maintain functioning economies to sustain the war effort, economists were called on to develop techniques and principles of economic control. The rapid expansion of wartime administrations required the best knowledge and skill in this field.

The war experience and its aftermath intensified all the problems of social

and personal breakdown which had engaged the attention of applied social scientists in the pre-war decades. Family disorganization, juvenile delinquency, displaced persons, problems of mental health and many kinds of social tensions challenged their knowledge and skills. The first director of the World Health Organization expressed the view that the world faced a race between the development of mature individuals able to function in the modern world, and the danger of being overwhelmed by the forces of destruction. The welfare state required the capacity to design sound programmes and institutions and to administer them well. The survival of predominantly capitalist economies clearly depended on their ability to prevent economic collapse.

Action along many lines was undertaken pragmatically, in response to need rather than on the basis of scientifically established knowledge or theory. But as social scientists tried to put their knowledge and techniques to work in all these areas, they found the opportunity to test in operation the body of knowledge which they had been building up and to expand it.

Under this stimulus both academic and clinical psychologists refined the techniques for psychological testing, opinion research and projective tests which they had evolved in the preceding years. Financial support from military and war veterans' service agencies drew a large proportion of psychologists into the clinical field and gave an important place to the problems that had been approached through methods of psychoanalysis or related techniques. A marked increase in the number of persons under treatment for mental illness tended further to reinforce this preoccupation. By 1950 some 50 per cent of the members of the American Psychological Association were at work in the clinical field, as against 10–15 per cent during the 1920s. Methods used by totalitarian régimes to break the will and 'brain-wash' political opponents and war captives gave rise to efforts to find principles which could be used in the training of military personnel to resist the effects of this scientifically-based assault on their integrity. The tremendous demands which supersonic planes and other modern weapons made on those who must operate them led to research into the conditions under which human beings could continue to function and exercise judgment. Evidence from this source as to the limits of psychological as well as physical strain added to basic psychological knowledge, as well as having practical implications for such matters as safety in civilian air travel and the management of personnel under less exacting conditions.

Anthropologists, called on both during the war and in the years which followed to analyse the cultures of enemies and others whom they could not study by their usual methods of first-hand investigation, developed techniques for using literary sources, testimony of emigrants and other available evidence. By these and more direct means they expanded the study of non-primitive societies which they had begun during the 1920s. In these years there appeared a large body of anthropological literature relating to France, Britain, Japan, the USSR, China, Germany, India, Norway, Rumania, a

number of Latin American countries and the United States, some written by anthropologists of the countries studied and some by those from abroad. The United States material was so extensive that the anthropological journal *American Anthropologist* devoted an entire issue (December 1955) to 'The U.S.A. as Anthropologists See It'. Meanwhile programmes of technical assistance in relation to the economic development of non-industrial countries further stimulated the kind of anthropological study which would throw light on the possible conditions for industrialization and the cultural impact of technical change.

Indeed, in these years the problems involved in the impact of technological change on non-industrial areas virtually held the centre of the social science stage. The so-called industrial revolution had come to Europe and North America gradually and at a time when the field of human behaviour had not been brought within the scope of scientific inquiry. By contrast the introduction of modern technology into underdeveloped areas in this period became a conscious process and its social impact a matter of grave concern, both to the countries undergoing development and to the agencies which were trying to make their aid effective.

Faced with the likelihood that efforts to introduce agricultural and industrial changes would meet with resistance, fail to spread beyond their initial point of impact or produce cultural and social disorganization, governments and international agencies called on social scientists to provide guides based on knowledge gained from past experience.* Special institutes such as the Research Centre in Economic Development and Cultural Change at the University of Chicago brought together economists, anthropologists and specialists in other fields to carry on research. The social science division of Unesco made this topic one of the two main centres of its work and organized a special programme for the study of the social implications of technical progress. A review of the expanding horizons in social science research in 1953† found this problem to be one of two principal directions in which the field was developing.

Scarcely less central was the effort to apply and expand knowledge and understanding of personality development. Psychologists continued to test Freudian and other hypotheses in an effort to develop a dynamic theory of personality. Studies of personality structure were at the heart of continued efforts to understand types of juvenile delinquency or the nature of prejudice. Psychologists joined anthropologists in the effort to determine the effect of culture on personality. Culture–personality studies initiated by followers of Franz Boas and Edward Sapir in the United States used psychological tools, including projective techniques, to discover personality characteristics in

* See *Cultural Patterns and Technical Change:* A Manual prepared by the World Federation for Mental Health, ed. Margaret Mead (Paris, Unesco, 1953); *Human Factors in Technological Change; A Casebook* (New York, Russell Sage Foundation, 1952).

† F. Stuart Chapin, *Social Science Research: its Expanding Horizons* (Minneapolis, University of Minnesota Social Science Research Center, 1953).

different cultures. They attempted to determine the mechanisms of personality formation used by different societies. They made comparative studies of child-rearing practices as clues to differences in adult personality, and tried to study 'national character', i.e. the modal personality types produced by different cultures.

Although these studies remained controversial and not fully developed, they represented by the 1950s a substantial effort to bring a scientific approach to these crucial questions. Following earlier attempts to focus attention on the effect of bureaucracy on its members by such sociologists as Max Weber and Ludwig von Mises (1881–), writers in the 1950s identified characteristics of the 'bureaucratic personality' as seen in *The Organization Man* (by William H. Whyte, 1956), *Mass Persuasion* (by Robert Merton, 1956), or the 'other-directed' individual in *The Lonely Crowd* (by David Riesman, 1950).

The importance of the problem of personality was clearly indicated when the 1950 meeting of the decennial White House Conference on Children and Youth in the United States chose as its theme 'a healthy personality for every child' in contrast to earlier conferences which had dealt with legal protection of children, their economic well-being and welfare services on their behalf.

A constellation of problems under the broad head of 'communication' also assumed growing importance. One facet through which the problem was approached was language. The *Gestalt* concept had established the need to know what is in the mind of the hearer or reader in order for the speaker or writer to evoke the meaning which he wishes to convey. The study of linguistics along lines suggested by B. Whorf (1897–1941) and Edward Sapir was carried forward by anthropologists and psychologists who examined language as a reflection of the thought-structure, values and attitudes characteristic of a culture. The images and stereotypes in which people thought and expressed themselves offered a key to understanding a culture and to the kinds of communication taking place within it. Language was also examined in terms of those features of inflection, stress or gesture which are integral parts of oral communication and essential to its full use and understanding. The ever-increasing need for communication among people of different cultures using different languages and modes of speech made the whole problem an exceedingly pressing one. Efforts were being made to devise electronic translators which would automatically convert words from one language to another; but at the same time the body of evidence was growing that many elements enter into the complex process of conveying meaning.

The problem of meaning especially preoccupied one branch of the study of linguistics known as semantics. By examining the ways in which changes in meaning have come about and the varieties of meaning which a word or phrase may have in a given context, scholars in this field sought methods to achieve more precise identity of meaning between speaker and hearer. either by the

choice of terms whose meaning is common to both or by establishing the sense in which each term is used at the time when it is employed. Such studies as *The Meaning of Meaning* by C. K. Ogden and I. A. Richards (1923) contributed to the development of theories of communication along two lines: the philosophical method of logical positivism and other forms of analytical philosophy, and the more popular consideration of communication in daily life.

A further approach to the subject of communication took the form of efforts to get at the essence of the idea or word or feeling that is being communicated —to discover its most elementary form. Communications engineers needed to know which of the sounds that enter into a word or sentence must be transmitted over telephone wire or radio wave if the meaning is to reach its destination and which sounds can be left out. The role of instincts in communication was studied in both humans and animals, by observations such as those to determine whether it is the shape of the mouth or some other aspect of expression that communicates a smile to an infant, or to identify the kind of shadow that tells a baby chicken when the shelter of the mother-bird's wing is at hand.

The extension of automation also had repercussions on communication research and theory. Automatic devices operate, in essence, by a system of signals; when a process reaches a certain point, say of temperature, distance or light, it sets off a signal which instructs a machine to stop, accelerate or turn, and this in turn may pass on other signals through endless complexities. Those engaged in communications research seized upon the concept of the automatic feedback, and directed attention to the built-in signals in the human mind which, like those in the automatic device, send back the messages which control the next thought or action. These and other approaches reflected a widespread recognition that communication was one of the central and imperfectly understood problems in all human relations.

Intensified study was also directed to the dynamics of small groups and the interrelations among groups, especially those involving group tensions. Interest in this area arose from the observation that in modern society the small group is the unit through which large organizations function, whether these be government agencies, corporations, labour unions or other associations. The individual—in school, on the job and in his social life—becomes a part of many such groups to which he must adjust and which affect his development; meantime the traditional groups of family, neighbourhood or occupation have lost or changed their traditional structure or role. The pioneer work of the refugee German, Kurt Lewin (1890–1947), in the late 1930s opened up for further study the question of the effect of democratic as against authoritarian leadership on the tensions among group members and the way in which the group as a whole performs.[7,8]

Political scientists added the concept of the 'group process' to that of 'line authority' in their efforts to evolve principles of administration and they

studied the factors affecting the manner in which group decisions are reached and the way in which group participation is related to performance on the job. Educators and others concerned with children investigated the role of group experience in the development of behaviour and personality. Those concerned with abnormal behaviour experimented with the use of group situations for therapeutic purposes. Sociometric techniques were designed for the observation and analysis of dynamic group relationships. All these approaches rested upon the assumption that the individual in industrial society cannot rely upon the role into which he is cast by birth or other circumstances, but must make and maintain his place through a variety of group relationships.

The interrelations among groups appeared as an equally pressing problem. Such insulation as had been provided in the past by distance or by clearly defined and commonly accepted status relationships was thoroughly worn away by technical and social changes. National, religious, class, racial, even age and sex groups confronted each other with immediacy and often conflict.[9] The problem of prejudice became a central concern to social psychologists who looked for its basis in personality structure, degrees of personal security or insecurity and types of social experience, as well as to sociologists who looked for its roots in social and economic structures and relationships. Unesco made the subject of tensions the centre of its first major social science effort.

In the field of political behaviour, two problems were of pressing importance in the post-war years: how to design international and semi-international entities which would redefine relationships among political units; and, in countries with democratic structures of government, how to make these institutions function effectively under conditions of modern technology. As governments took on many technically complex functions and intervened in a great many aspects of life, it became difficult to maintain a relationship of responsibility between an elected representative and his constituents. The interests of the constituents often were in conflict one with another on matters on which the representative was required to act. It was difficult for voters to be informed on the intricacies of technical problems or to find a means of expression when they were. In newly established states whose constitutions prescribed democratic machinery, the people lacked political experience and in addition were separated from the political leadership by a wide gulf of education. These problems were so charged with political emotion and so enmeshed in the struggle for power as to intensify the difficulties of subjecting them to systematic study.

For capitalist economists the major problem was how to maintain a high-level, expanding and stable economic system. The decade following the second world war provided a first test of whether enough economic understanding had been achieved to enable the capitalist countries to avoid a post-war depression. In the countries affected by the depression of the 1930s the recovery measures adopted prior to the outbreak of war had not wholly

succeeded in eliminating unemployment. When the war ended, therefore, Marxian economists, and many others as well, confidently expected a slump. It was well recognized, however, that no government could afford to let depression descend upon its country or on countries with which it was intimately related. Even the United States, which maintained more strongly than most others a policy of keeping government intervention in economic affairs to the minimum, declared in its Employment Act of 1946 that the maintenance of full employment was a matter of public policy and government responsibility.

As the economy of the United States remained at a high though fluctuating level of operation and those of western Europe and Britain recovered and flourished, they provided an opportunity to refine and to test further the concepts and techniques evolved in the later years of the great depression of the 1930s. The most important of these techniques related to the use of fiscal and monetary policies to counterbalance economic fluctuations and procedures for arriving at quantitative estimates of economic relationships as a basis for some degree of economic planning. To what extent continued economic stability and growth was due to heavy military expenditures was a matter of dispute. But the experience of the 1950s made it appear that economic knowledge was at least beginning to yield techniques for maintaining in dynamic equilibrium an expanding industrial economy without the authoritarian direction of a centralized state.[10, 11]

The wartime experience in which the combined skills and resources of many specialists were brought together on common problems greatly strengthened the tendency toward integration, or at least co-operation, among the several social science disciplines. Many scholars prepared themselves in more than one field; virtually all research projects of any magnitude enlisted a team of different specialists; a series of interdisciplinary institutes were established to conduct studies of special areas, or to focus on major social problems such as the economic development of non-industrial countries, urbanism, population. The Social Science Research Council in the United States sponsored committees on which several disciplines were represented to explore needs for research on the frontiers of social science knowledge. The teams enlisted by international agencies for their projects were usually drawn from many fields as well as from many nations.

The stimulus of interdisciplinary research was reflected in renewed efforts to build a common social science. In the first half of the twentieth century there had been few efforts to build broad systems such as those which had characterized such nineteenth-century thinkers as Hegel, Comte and Herbert Spencer. Those who sought to apply scientific method to the study of human behaviour expanded the frontiers of knowledge piece by piece.

As the researches of different disciplines led to areas which were being explored by others, as concepts were borrowed and as techniques of research became common to several disciplines, scholars began to search for general

system theory which would incorporate the findings of the several social sciences and provide a common basis for research. The quest for a common core preoccupied some scholars within each discipline, although others felt that the tendency to combine fields might interfere with the necessary task of refining the still very imperfect methods and theory of each.

2. *Refinement of research techniques*

Research techniques in use in these years were in general superior in each of the social science fields to those in vogue twenty or thirty years before. Loosely descriptive sociological studies had been replaced by more sharply focused inquiries. Refined techniques had been developed for sampling populations, evaluating statistical errors in the manipulation of data and analysing and correlating multiple factors. The research interview had been systematically tested and the relation between verbal response and both behaviour and attitude had been explored. Often with the aid of recording devices, techniques of participant observation and of action research had been refined. Scales had been devised for recording the intensity as well as the content of attitudes and opinions, and procedures were designed for detecting the nature and effectiveness of communication.

Observation and analysis were beginning to be used as a basis for prediction. While the opinion poll based on careful sampling did not prove to be a sufficiently accurate instrument to predict the results of a really close election, it demonstrated substantial usefulness for forecasting behaviour. Other techniques for the prediction of political behaviour were developed on the basis of past voting records. Statistical methods which had first been used to predict the production, consumption and prices of agricultural products in the United States proved valuable when used to forecast American elections.

Essentially similar methods provided means for the prediction of economic behaviour. Techniques of statistical correlation were applied to series of economic data in order to establish relationships and to make it possible to predict the reactions of some factors when others were changed. In conjunction with studies of national income, such studies provided a basis for economic planning and for tracing through the impact of specific monetary or fiscal policy or change in investment, consumption or production. They were indispensable tools in programmes designed to expand real income of both industrialized and non-industrialized countries. In the years following the second world war such techniques were applied by the economic development agencies of many countries, in evaluating requests for international assistance by the International Bank for Reconstruction and Development, and to provide information in the light of which business men could make their private decisions.

Efforts further to refine methodology took a variety of directions, and some basic differences, especially with respect to techniques of observation, were unresolved.

One division was basic. Most anthropologists, archaeologists, historians and clinical psychologists sought always, first of all, to observe and understand the unique event, culture or individual; experimental psychologists, sociologists and economists, on the other hand, aimed to abstract from the particular in order to establish general relationships. The first group sought to make the trained observer a more refined and sensitized instrument to detect meanings that would elude detection by other means; the second group depended mainly on the improved handling of quantitative data.

A second division was between those who sought means to isolate specific phenomena more precisely in order to subject them to rigorous scrutiny, and those who thought that the phenomenon to be studied was exactly the complex of interrelationships itself. The latter emphasis corresponded in part with interest in the unique situation, for anthropologists were among those who most distrusted generalizations based on treating items as independent, self-contained elements, preferring completeness of context to disembodied precision. Economists too, however, became increasingly absorbed in the search for means to express complex interrelationships in order to cope with the intricacies of economic planning.

A third division, which followed no line between disciplines, concerned the role of the observer. Should he seek maximum detachment and objectivity or should he consciously recognize the nature of his intervention on the theory that detachment is in fact impossible and that every effort to observe human behaviour distorts the behaviour itself, as for example when a poll to determine voting intentions creates the impression that one candidate will win and thereby changes the intentions it was designed to measure. Historians, who had been most insistent on letting facts speak for themselves, came to accept the idea that every historian necessarily brings to his study of the past the outlook and preoccupations of his own time; they differed in concluding that the only order in history is that which the individual historian imposes on the events he describes, or in hoping that by recognizing and acknowledging bias a measure of objectivity can nevertheless be achieved. In all fields there was a growing recognition that, perhaps as much as in nuclear physics, the process of observation so enters into the behaviour which is studied as to make the observation itself an inevitable part of the answer.

With respect to the handling of data, interest remained general in methods of sampling, correlation and probability analysis and the refinement of mathematical statistics. Those like the anthropologists who insisted that it was the combination of factors—the 'event'—rather than the separate items or traits that required observation and analysis looked to the newer branches of mathematics, such as topology, in the hope that they would supply techniques of analysis which probability principles alone failed to offer. The device of model making, most familiar in the field of economics, was adopted in other fields, and by those who were concerned with general theory. Models of hypothetical behaviour were designed on the basis of observed relationships and

general principles, and were used to make predictions and to test such predictions of future behaviour by observations under controlled or uncontrolled conditions. The development of electronic computing devices opened up great possibilities for the handling of data by permitting the rapid analysis of complex interrelationships. With the aid of these devices matters such as the multiple factors affecting voting behaviour or the complex phenomena of juvenile delinquency were beginning to be subjected to analysis in the effort to detect the combination which had value for prediction.

3. *The social sciences at mid-century*

As it became increasingly clear, after two world wars and the development of ultimate means of destruction, that natural science in and of itself would not lead mankind along the path of progress which the nineteenth century had envisioned, the social sciences began to be looked to for aid in seeking solutions to the world's ills. The public showed ambivalence in an exaggerated confidence and an exaggerated distrust of what social science had to offer.

Social scientists themselves were not in agreement as to their potential role. While some thought that the application of social science knowledge and techniques in policy-making and administration held great promise for human welfare, others insisted that, like natural science, social science is neutral and that social scientists, equipped with knowledge but not necessarily with wisdom, can only inform and not guide.

In general, social scientists at mid-century were addressing themselves to urgent social problems, their services were in wide demand, and major funds both from governments and from foundations were being dedicated to expand the frontiers of knowledge in this field. The more modest among them agreed that they had developed a variety of techniques of investigation, increasingly refined, flexible and rigorous, which lent themselves to answering practical as well as theoretical questions, that they had amassed a growing fund of empirical facts which often had practical usefulness, and that they had gained increased sophistication about the variables or factors likely to be relevant to any given problem.

As compared with the fields of the natural sciences, however, knowledge of human behaviour was still very limited. Social scientists themselves were saying '. . . the social scientist knows more accurately than do other people the extent of our ignorance about man and human affairs. The social scientist is thus at the beginning of knowledge'.* The social sciences had not yet achieved a coherent body of theoretical generalization into which new research could be integrated, and through which new studies could be systematically related to previous research. Research continued to be carried on without reference to the work done by others; social scientists might disregard the findings or terminology of their fellow scientists with impunity, as no responsible natural

* F. Osborn, 'The social sciences in the service of man' in *The Social Sciences at Mid-century* (University of Minnesota Press, Minneapolis, 1952), p. 4.

scientist could do. Yet they had established, and gained widespread though not universal acceptance for, the idea that 'the behaviour of man, like the behaviour of materials, is characterized by certain uniformities and patterns that can be studied systematically'.* In so doing they had broken through the attitudes which had taken for granted existing forms and values and had made a start, however limited, toward understanding and coping with the processes of social change.

V. SOCIAL SCIENCE AND SOCIAL ACTION

As new knowledge of human behaviour was developed, it was unevenly applied. At times it was ignored while at other times the urgency with which social problems pressed for solution led to the application of very partial and untested knowledge and to frequent changes in technique.

In the main, social institutions evolved pragmatically in response to the practical need to cope with the problems which industrialization brought and under pressures from groups and strata of society which had formerly had no voice or political role. The rapidly changing conditions of urban industrial society required conscious steps to deal with many aspects of living, for which custom, folk knowledge, religious precept and family structure had largely provided in the past. The democratic spirit contributed a favourable milieu, for concern with the welfare of all the people required knowledge of their lives and systematic measures to meet their needs. Age-old conditions which had been taken for granted as normal aspects of life became 'problems' for twentieth-century man to solve or 'ills' to be remedied. Revolutionary societies undertook to redesign basic social relationships and to develop new men and women for a new age.

In these circumstances every resource of experience or knowledge was drawn upon by public agencies, organized groups and individuals, and the social sciences, whatever their limitations, were applied increasingly in virtually every realm of social life and human relations. They were carried into the home, to affect the processes of child rearing, home making and family planning and to protect and strengthen the family against the pressures of modern life. Control of the environment was attempted through the provision of city facilities and services, housing and measures designed to control urban growth, and by the extension of services and regulation to rural or semi-rural areas. Measures were adopted to treat, and if possible to prevent, the many forms of social breakdown which the impersonal, changing industrial societies threatened to produce, including provisions for security against the hazards of illness, incapacity, old age and the loss of the breadwinner, treatment of mentally and socially maladjusted individuals and the control of delinquency and crime. Knowledge of human behaviour was invoked in efforts to lessen

* C. Dollard, 'Strategy for advancing the social sciences' in *The Social Sciences at Mid-century*, p. 12.

tensions and facilitate interrelations among economic, racial and other divergent social groups, to promote economic stability and development, to improve communication, to exercise political influence and administrative direction and to market products through advertising.

New social professions arose and the scope of older professions was extended to incorporate new social knowledge. Professional services based on the application of social science knowledge became part of the institutional structure of industry, education, law enforcement and community life.

Behind all measures to apply social techniques lay the central problem of how social change actually does take place. Most study and effort at application outside the communist-dominated areas rested on the view that social change is necessarily a slow process in which old institutions, behaviour patterns and attitudes gradually adapt themselves to new situations; according to one widely held assumption, material changes take the lead, with social institutions showing a 'cultural lag'.

As countries tried to bring about a rapid transformation of their societies, however, there was a growing interest in examples of drastic social change which might throw light on how the social gap between advanced and backward areas might be quickly and effectively closed. Such examples were being studied on the hypothesis that a sudden and complete change involving the totality of interrelated factors, a sort of social mutation or break-through—as in the modernization of a primitive society or the complete remaking of a village by concerted effort—might be more effective than piecemeal changes each of which would tend to be dragged back toward old norms by the weight of other institutions. One school of thought insisted that partial transformations of non-industrial societies brought only disorganization and pauperization and that nothing short of complete remaking could save them from degradation.* In the Marxist–Leninist view revolutionary change involving the socialization of the means of production was the historically necessary basis for a transformation of society in which the fruits of science and technology would be used for the ultimate benefit of all.

The central problems at mid-century were twofold: would the social sciences provide sufficient understanding of human behaviour and adequate techniques for social action to meet the requirements of a highly mobile, interdependent world armed with great knowledge and power over physical and biological processes; and would knowledge of human behaviour be used to enhance or thwart human development?

Any attempt to trace the application of the social sciences during these years encounters the obvious difficulty that social changes are the product of many forces of which the conscious use of social theory and knowledge of

* For example: Margaret Mead, *New Lives for Old: Cultural Transformation—Manus, 1928–1953* (William Morrow & Co., New York, 1956); *Development of the Local Community of Nayarit* (United Nations, New York, 1954); Germaine Tillion, *Algeria; the Realities* (Knopf, New York, 1958).

social behaviour is only one small element. New knowledge of human development and behaviour was indeed consciously used in the rearing of children; but the experience, status and outlook of the young was more profoundly affected by broad changes in family life accompanying the growth of industry, cities, travel and communication, by the impact of war and revolution and by changing social values arising from cultural contact and social change. Efforts to deal scientifically with the urban environment played a minor role in the development of cities as compared with the pull of employment opportunities and the enterprise of merchants, realtors and purveyors of the myriad services which contribute to city life. Social science knowledge was perhaps most consciously applied in efforts to deal with social breakdown, for it was the need to cope with delinquency, crime, dependency and social disorganization which stimulated much of the research in the field. But here, too, practical measures based on custom and common sense continued to overshadow those which rested on tested observation and theory.

The three chapters which follow must therefore be read in conjunction with the chapters of Part II which examine the institutional changes resulting from the interaction of all the forces at work during these years, and also in relation to the chapters dealing with the physical and biological sciences, since the application of knowledge in these fields had, indirectly, a far more profound impact on social life than the direct application of the social sciences themselves.

NOTES TO CHAPTER XVI

1. Doctor of Philosophy V. Kolbanovsky says that the main stimulus that drove men to seek deeper knowledge of human life and more effective and systematic means of satisfying popular needs was the emergence on the political scene of new classes and social strata. As a consequence of this development a number of democratic measures were carried out, under the pressure of the popular masses, and new social forces arose to take part in social conflicts. Unfortunately bourgeois social science paid no attention to the methodology developed already in the middle of the nineteenth century by Marx and Engels for the scientific study of social problems (see note 10 to Chapter VI) and the vast material accumulated on such questions by Marxist-Leninists.

2. Doctor of Philosophy V. Kolbanovsky points out that the intensified interest in sociological research generally observable in the 1920s and 1930s, and the attempts made to intervene actively in economic and social matters with the aid of data provided by such studies, were to a very important extent stimulated by the deepening of social and economic contradictions in Western Europe and North America at this time. But only in the Soviet Union, which had established public ownership of the means of production and where men were armed with Marxist-Leninist theory, was it possible to establish genuinely comprehensive long-term planning of the economy of an entire country.

3. Professor E. N. Anderson states: The role of Sigmund Freud should be seen in two dimensions: (1) in his direct contribution to the development of psychoanalysis as a technique of scientific investigation and of clinical treatment, and (2) in his indirect influence on other behavioural sciences through the use of his theories, in their original or modified forms, as working hypotheses in these other fields. The Author-Editors have not distinguished clearly these two lines of influence. Creator of psychoanalysis as a scientific study, Freud inspired and trained practically all of the first generation of practitioners, whether Austrian, German, Swiss, French, British, or of other national origin. These followers spread into other countries from Vienna, and under the menace of Nazi persecution many emigrated to the New World, especially to the United States, fortified in their conviction about the power of the subconscious, the irrational, by the evidence of totalitarianism. The experience which they received as they moved or fled into other cultures, and which differed so much from that in Freud's pre-war Vienna, made many of the master's followers aware of the conditioning factor of culture upon the character of neuroses and led to the rejection of some of Freud's theories in favour of views deduced from the experience of new environments. The psychoanalytic school was divided into those who remained convinced of the validity of Freud's ideas and methods of analysis and therapy and those who developed their own modification of Freud or even new theories. Critics were found particularly in the United States, but European countries had and have distinguished representatives as well.

   With respect to the application of Freud's theories into other fields, there is scarcely a social science or a humanistic discipline which has not felt the stimulus of this thinker. Much of this adaptation of Freudism has been in the realm of speculation, much has been popularization, in both instances without the clinical control which Freud employed in his researches, but even this application has often been fruitful. One can scarcely conceive of studying political life under National Socialism, for example, without the use of Freud's basic views, and the abuse (or too easy generalization from too little knowledge) of Freud has not prevented essential research from being done in crossing psychoanalysis or psychiatry and anthropology, for example, as revealed in the works of Abram Kardiner and by others in Europe, in America and elsewhere.

   For further reading see:

Franz Alexander and Helen Ross (eds.), *The Impact of Freudian Psychology* (Chicago, 1952).

A. A. Brill, *Freud's Contribution to Psychiatry* (New York, Norton, 1962).

Erich Fromm, *Sigmund Freud's Mission: An Analysis of His Personality and Influence* (New York, 1959; Belmont Books, No. 51, 1963).

Sidney Hook (ed), *Psychoanalysis, Scientific Method and Philosophy: A Symposium* (New York, Evergreen No. 261, 1960).

Ernest Jones, *Sigmund Freud. His Life and Work.* 3 vols. (London, 1953–57).

Abram Kardiner and Ralph Linton, *The Psychological Frontiers of Society* (New York, 1945).

Bruce Mazlish (ed.), *Psychoanalysis and History* (Englewood, N.J., 1963).

John Sutherland (ed.), *Psychoanalysis and Contemporary Thought* (New York, Evergreen No. 164, 1959).

4. Doctor of Philosophy V. Kolbanovsky notes that the account given here of the 'triumphant progress' of Freudian ideas in Western sociology is exaggerated, to say the least. The wholesale penetration of the social sciences by Freud in all its modifications and manifestations (Freud, Adler, Jung, Horney, Sullivan and others) is contested by a number of leading authorities. Some of them, such as H. Wells, Furst, and others, have subjected Freudian concepts to radical revision and have refuted their claim to provide a solution of clinical and social problems. Others, while accepting Freud's psychological and psychiatric ideas, have never taken seriously his essentially myth-making investigations in the field of social theory—as, for example, in the question of the origin of the family or totemism. It should be very strongly emphasized that the concept of psychoanalysis involves the extension to the sphere of social relations of data obtained from clinics for the treatment of nervous and psychiatric disorders, which are given a one-sided interpretation. As is well known, psychoanalysts regard broad social movements or manifestations of the class struggle as nothing other than a case of collective neurosis or mass hysteria, and outburst of unsublimated psychic energy from the depths of the subconscious which has not been directed in time into the proper channels.

   The inner logic of such ideas is obvious: for if social phenomena are identical with those of the individual psyche, it is easy to show that many of their manifestations can be treated as pathological cases, as deviations from some conventional form. At this point one may recall the criticism made by the Russian physiologist I. P. Pavlov of the works of the German psychiatrist Ernst Kretschmer. Although it is unquestionably the case that E. Kretschmer's idea of characterology was based on much more solid material than the fanciful concepts of the psychoanalysts, I. P. Pavlov justly pointed out that it was not permissible to take clinical observations and apply them to the lives and activities of normal human beings. Still less permissible is it to take conclusions arrived at on the basis of clinical observations and apply them to the realm of social processes. For I. P. Pavlov's critique of E. Kretschmer's propositions, see I. P. Pavlov, 'Obshchie tipy vysshey nervnoy deyatelnosti zhivotnykh i cheloveka' (Types of Higher Nervous Activity Common to Animals and Man'). *Poslednie soobshcheniya po fiziologii i patologii vysshey nervnoy deyatelnosti* (Recent Communications on the Physiology and Pathology of Higher Nervous Activity), Communication III, 1935; *Pavlovskiye sredy* (Pavlov Discussions), Vol. III (Moscow-Leningrad, 1949).

5. Candidate of Juridical Sciences A. E. Bovin points out that the approach of the crisis of 1929, and its inevitability, were predicted by Marxists. Documentary proof of this is contained in the materials of the Fifteenth Congress of the VKP(b) (All-Union Communist Party (Bolsheviks)), Sixth Congress of the Comintern (1928) and Tenth Plenum of the Executive Committee of the Comintern in July 1929.

6. In the opinion of Doctor of Philosophy V. Kolbanovsky Keynes' ideas should be seen as an attempt to revive the authority of vulgar political economy in the new conditions of large-scale production and state-monopoly capitalism. As the experience of the last decades has shown, the measures put forward by Keynes have not given the capitalist economy security against shocks. Keynesian economics can temporarily conceal the traces of decline, but cannot prevent impending catastrophe.

7. Doctor of Philosophical Sciences V. Semenov thinks that including an individual in various 'small groups' does not detract from the necessity of analysing the social structure in terms of classes. The views set forth in the text are typical of those propounded by bourgeois sociologists anxious to prove that the conclusions of Marxism on the class structure of capitalist society are allegedly 'obsolete'.

   The most widespread point of view among bourgeois sociologists studying developmental tendencies in the social structure is that in capitalist society class antagonism is disappearing on account of the 'social mobility' prevailing in that society. This concept of 'social mobility' proceeds from an anti-scientific treatment of the nature of classes,

whereby class differences are ignored in favour of differences that are secondary and derivative. Bourgeois writers ignore the main criterion of class allegiance—relationship to the means of production—and thus deny the irreconcilable nature of class contradictions in capitalist society.

The term 'mobility', as applied to social life, is used very loosely by bourgeois scholars to refer to all manner of social displacements. They make a distinction between 'physical mobility' ('the movement of population elements . . . from one place to another') and 'social mobility' (the movement of individuals or groups from one social position to another in a constellation of social groups and strata) (see P. Sorokin, *Society, Culture and Personality*, New York and London, 1947, p. 405.) 'Social mobility' in turn is divided by bourgeois writers into 'horizontal' and 'vertical' mobility. 'Horizontal social mobility' is the transition of an individual or family from one social group to another at the same social level or stratum (see *ibid.*, pp. 398–9, 405). For example: a shorthand-typist leaving one insurance company for another, a worker leaving Ford for General Motors, an agronomist leaving one farm for another, and so on.

Such mobility does indeed take place in capitalist society, but of course it does not nullify class contradictions. So much is apparent to the bourgeois scholars themselves. Their attention is concentrated on 'vertical social mobility', by which they mean 'the shifting of an individual, family, or even larger group from one stratum to another in the pyramid of social stratification' (see J. O. Hertzler, *Society in Action: a Study of Basic Social Processes*, New York, 1954, p. 237). Bourgeois scholars list six 'channels' or 'elevators' of vertical social mobility 'which enable individuals to move up and down the social ladder': (1) 'economic institutions', i.e. the whole economic life of society; (2) the army; (3) the church; (4) various 'political institutions' (the state apparatus, the apparatus of the parties, the totality of political institutions and organizations); (5) 'the educational system'; (6) marriage.

But if such movement into the 'upper' strata through the so-called channels of mobility does indeed occur in capitalist countries, this only affects individuals and is not a law of social life. Such 'movements' cannot lead to the liquidation of classes, the class struggle, and the exploitation of man by man. Moreover, bourgeois ideologists frankly acknowledge that all these 'channels of vertical social mobility' (economic institutions, the educational system, etc.) are a sort of 'selective agencies' in the hands of the ruling class. 'These institutions', Hertzler writes unequivocally, 'also serve as sifters, testing and selecting, sorting and grading these persons of the population and distributing and locating them on the strata' (*ibid.*, p. 238). The reality of life under capitalism shows that no mass 'movement up' of working people takes place in fact. On the contrary, most of the working population are faced with a real threat of 'movement down', to ruin and poverty.

Even bourgeois investigators are compelled to admit this in one form or another. 'Hence, the difficulty of not only rising in the social scale but also of holding one's own becomes greater', writes Hertzler (*loc. cit.*).

What is actually taking place in capitalist society is a process whereby the population is moving in the main into the ranks of the proletariat. This not only does not lead to extinction of the class struggle, but on the contrary serves as one of the means for accentuating it further. The struggle of the workers, which increases in intensity from year to year, is the most eloquent proof of the falsity of the assertions made by bourgeois scholars to the effect that in capitalist society the class struggle 'is being eliminated'.

In these conditions any social theory which in one way or another seeks to by-pass the fundamental and decisive class division of society is scientifically worthless.

8. *The Author-Editors note that the data upon which sociologists in the United States and elsewhere base their theories with respect to social stratification include the trends in occupations, income distribution and relative earnings of industrial workers and professional persons in the United States which are shown in the Author-Editors' supplementary note 2 to Chapter V.*

9. In the opinion of Doctor of Philosophy V. Kolbanovsky among the social groups mentioned here the most important and fundamental are classes. See note 7 above.

10. As the fifteen years since the end of the second world war have shown, writes Doctor of Philosophy V. Kolbanovsky, the capitalist countries have only been able to ease their economic difficulties by engaging in increased production of armaments, and despite

this the USA has not succeeded in avoiding periodical declines in the level of business activity. Therefore the 'dynamic equilibrium' of the post-war years is extremely unstable, since it is founded not on 'economic knowledge' but on the expansion of the armaments industry. See note 9 to Chapter IX and note 1 to Chapter XXI.

11. *See the Author-Editors' supplementary note 2 to Chapter IX.*

12. In the opinion of Professor E. N. Anderson, the Author-Editors may be criticized for not including in this chapter a discussion of the efforts of economists to analyse stages of economic growth and to identify the factors responsible for this growth. Scholars have endeavoured since World War II to identify these stages, for economically under-developed countries have sought means to accelerate the rate of their development, and economically advanced countries and international agencies offering technical and financial assistance to them have needed to know—in order to apply aid effectively—what are appropriate elements of growth.

The most discussed of the efforts to identify stages of economic growth has been the formulation of W. W. Rostow in *Stages of Economic Growth* (Cambridge, 1960), where he characterizes five stages: that of traditional society; that of the pre-conditions for take-off; that of the take-off; that of the drive to maturity; and that of the age of consumption. Although Rostow's analysis has been stimulating and fruitful in the search for criteria with which to compare the conditions and to gauge the needs of various countries of the world, the concept of 'The Take-Off into Self-Sustained Growth', for example (*Economic Journal*, March, 1956) has been subject to adverse criticism and to difference of opinion.

One may consult:

W. W. Rostow (ed.), *The Economics of Take Off into Sustained Growth: Proceedings of a Conference Held by the International Economic Association* (London, 1964).

CHAPTER XVII

THE HOME

THE home, from its physical aspects and daily routines to its child-rearing functions, its human relations and its economic basis, became a field for scientific study, for the application of scientific knowledge and for the development of practices designed to enable it better to serve its functions under modern conditions.*

I. CHILD STUDY

The growing knowledge about the processes of learning and conditioning which came out of the psychological laboratories in the early years of the twentieth century led to a movement to bring a more scientific approach to the rearing of the child.

In all societies, child-rearing practices have constituted an important part of the body of knowledge handed on from generation to generation. Generally these practices have been learned by girls from their mothers in the home and absorbed from the conduct of adults toward children and the expectations to which children have learned to conform. In static societies these child-rearing practices have been a principal means for maintaining the patterns and values of the society and shaping the types of personality demanded by it. In most societies the child has occupied a secondary position as an immature or incomplete adult, a possession or a servant to be used by its parents, on the fringe of society—according to the adage that 'children should be seen but not heard'—and as something to receive the impress of the adult world. His physical care has been based upon folk practice and knowledge, and his emotional development taken for granted. His mental and moral training has been the principal object of conscious attention and educational theory.

In many western societies at the opening of the twentieth century the mental and moral aspects of child training were governed generally by the precepts and practices of the Church and by educational principles which had been modified from the time of the Renaissance by such philosophers and educators as Johann Comenius, John Locke, Jean Jacques Rousseau, Johann Pestalozzi and Friedrich Froebel. Theories of child rearing were based on varying assumptions as to the child's nature: that he was depraved and must be corrected from the start; that he was by nature good unless spoiled by society; or that he was a *tabula rasa* without innate tendencies on whose blank

* For changes in the family as an institution, see Chapter XXII, Social Institutions; for the development of education, see Chapter XXVI, Education; for maternal and child health, see Chapter XV, Health.

surface character and knowledge were to be imprinted. In other societies traditional ways of fitting the child to his family and his station in life were deeply ingrained and of long standing.

To these the twentieth-century approach to child rearing added: a new position for the child as a figure in his own right and a central rather than a peripheral member of society; recognition that in a rapidly changing society it is not enough to teach him to reproduce the pattern of behaviour of his ancestors—he must be equipped with the security, flexibility and knowledge which will permit him to make his own choices and to shape a new and different social order; and a new understanding of the processes of growth and development, especially of the emotional component which had been largely taken for granted or consciously ignored and now became a central factor.

Impetus for the conscious application of new knowledge to child rearing was strongest in those countries where the culture was most child-centred and the assumption of change most general. But in the course of this half-century a basic reorientation in the treatment of the child and in the concept of his role, and some modification of child-rearing practices in the light of modern knowledge, spread around the world. One of the first publications of the World Health Organization was in this field.* In many countries, children came to be considered as the instruments of a new day, especially in revolutionary societies during early stages of the revolution and in the developing countries at the point where they shifted psychologically from a static to a dynamic approach to social change.

The new ideas and attitude toward child rearing even reached and modified the culture of the most remote areas. In 1953 the anthropologist Margaret Mead returned to the Admiralty Islands in the south Pacific twenty-five years after she had gone there to study the culture of a people untouched by any of the major civilizations. When she had left there in 1928, they had beaten the death drums to sound her departure for a world which was to them 'stranger than the abode of their dead'. On her return, she was greeted by the school teacher and a local official who asked her to check a long set of rules for modern child-care, feeding, sleeping and discipline which they had written down as best they could from their memories of what they had been told and what they had seen the wives of Australian officials doing in the ports. Dr Mead reported:

'When I explained that my comments would be in terms of the latest thinking on the matter as developed in the International Seminar on Mental Health and Infant Development, held at Chichester, England, in 1952 under the auspices of the World Federation for Mental Health and the World Health Organization of the United Nations, *he understood what I was saying*.'†

* John Bowlby, *Maternal Care and Mental Health* (WHO Monograph Series, Geneva, 1951).

† Margaret Mead, *New Lives for Old*, p. 23.

In the early years of the century a protest against the traditional attitude toward the child was voiced by the Swedish feminist, Ellen Key (1849–1926). Her *The Century of the Child* (Barnits ärhundrade, 1900) was widely translated and heatedly discussed. Nine years later, when Maria Montessori (1870–1952) offered a positive training method based on her observation of the mental and emotional development of young children in the Casa dei Bambini in Rome (*Il metodo della pedagogia scientifica*, 1909), her ideas found acceptance in many quarters. She stressed the value of self-activity and individual work combined with community living and mutual help, and the importance of offering the child a stimulating environment to arouse and train the senses and elicit an active response.

Shortly before the first world war a movement for popular child study took shape with the formation of child-study associations and groups in a number of places. These associations focused their interest on the normal child rather than the child with abnormalities or in need of special care or protection; they were concerned with his total development as a person rather than with the problems of effective training with which educators were primarily concerned. Their aim was to study the implications of scientific findings for the care and formation of the child in the home and to impart to parents, through a broad programme of adult education, an understanding of the child and some of the precepts which such understanding implied.

Initially, material relating to learning and conditioning was the chief scientific source on which they drew, and they placed much emphasis on regularity and system in the child-training process. As detailed observations of child development were provided by work in various research centres, emphasis was placed on adjusting the demands made upon the child to his stage of development and readiness to respond.

When the influence of Freud began to spread, the implications of his findings for the child's emotional development came to occupy a central place. His emphasis on the relationships established by the child in earliest infancy gave central importance to the emotional security and response which the infant receives; the warmth and love of the parent and the child's sense of continuing well-being were seen as more essential to his total growth than the regularity of his toilet training and the strictness of his feeding schedule. It appeared also that parents could damage their children unintentionally by pressing them too soon to conform to norms of behaviour beyond their level.

Comparative studies by anthropologists of child-rearing practices in different societies also called into question some of the commonly accepted training techniques. By mid-century many of the concepts of child rearing which had reflected an attempt to apply scientific knowledge during the first quarter of the century had become outmoded and had been replaced by concepts based on later knowledge supplied by anthropology and psychology.

The change was interestingly reflected in the various editions of the widely distributed bulletin, *Infant Care*, published by the United States Children's

Bureau. The initial version, first published in 1914, stressed training aspects, with emphasis on regularity of the child's habits. But during the 1930s many of the precepts contained in the volume came into disfavour as placing the child under restraints and pressures which could do emotional damage, and they were recognized as doing more for the convenience of the parent than for the sound development of the child. In successive revisions in 1938 and during the 1940s and 1950s parents were encouraged to be more permissive and relaxed in dealing with their children, and some of the principles set forth were quite opposed to those of the earlier edition. Meantime, translations of the earlier rather than the later editions circulated in some places, notably in Latin America.

The channels through which child-rearing concepts entered the stream of common knowledge were many and various in different parts of the world. As it became apparent that the home alone could not always be counted on to prepare young people adequately for marriage and parenthood, schools began to include in their curricula both sex education and pre-marital education with respect to such matters as family life and child rearing, or to sponsor supplementary educational activities in these fields. Maternal and child health programmes were as much concerned with maternal education as with actual clinical treatment of mothers and young babies. The educational component of maternal and child health programmes, moreover, came to include the understanding of the child's emotional needs, in addition to hygiene and nutrition which were their original focus.

Studies of child development carried on by technical specialists through very careful observations provided the basis for a number of books designed to aid the parent in recognizing the normality of his child's behaviour and to guide his own handling of the child. The books of Dr Arnold Gesell of Yale University (*Infant and Child in the Culture of Today*, 1943) and Dr Benjamin Spock (*The Common Sense Book of Baby and Child Care*, 1946) became handbooks for thousands of parents. Doctors and educators wrote regular columns in newspapers to offer advice and to answer the questions of parents; magazines of all sorts—not alone women's magazines—featured articles relating to child development and adolescent behaviour; the theme became a familiar one on radio and television. In virtually all educational programmes directed primarily toward women, child care and child rearing were featured. Perhaps no other body of new knowledge was more eagerly sought or more widely disseminated in some form in most parts of the world.

The effect of all this was sometimes to make parents anxious lest they fail to do the right thing for their children. Their very effort to follow the latest guides and to behave as model parents sometimes produced such tension that their efforts were self-defeating. Critics of modern parents accused the latter of being afraid of their children and of failing to offer them the firmness and discipline which they needed and really desired. But few modern parents thought it practical to try to return to old ways under the conditions of new

times, and most agreed with Mrs Sidonie Gruenberg, one of the founders of the child-study movement, who had insisted in 1913: 'We need not fall into the all-too-common error of placing common-sense and practical insight in opposition to the method of the scientists.'*

II. HOME ECONOMICS

Paralleling the child-study movement, and intertwined with it, were other lines of development which sought to apply the fruits of scientific study to home and family life. 'Home economics' or 'home science' became a professional and educational field, and recognition of the changing structure and functioning of the family under modern conditions led to educational and welfare programmes to promote family stability.

Home economics had its major development in the United States and Canada, and also in Australia, New Zealand and the Scandinavian countries. In most European countries housekeeping continued to be regarded as a technical skill and the term 'home economics' was only introduced as an Americanism after the second world war; nevertheless, the curricula of the training academies were expanded along similar lines. The approach developed by the professional home economists spread to a number of Latin American, Asian and African countries after the second world war and was adopted in these areas as a part of their efforts to reconstruct their traditional societies.

The conception which guided the development of the field of home economics in the United States was that formulated at the turn of the century by Ellen H. Richards (1842–1911), who saw the home as providing a nurturing environment for the child and a haven for adults, and as depending for support on the society of which it was a part and giving to society the fruits of family living. Although she was herself a food chemist, her main concern was with the social and spiritual aspects of the home and she saw the application of scientific knowledge to the physical needs and the mechanics of the home as helping to provide the health and leisure essential to good home life.

With this broad concept home economics teachers and professional practitioners drew from one field of science after another as new bodies of knowledge relevant to the home became available and new awarenesses of needs and possibilities dictated new emphases.

The first concern was with food, especially the feeding of infants and children. Knowledge of food chemistry, bacteriology and physiology was included in school instruction and in advice to mothers, and was marshalled in support of pure food laws and regulations to guard against the offering of unsafe or adulterated foods on the market. As knowledge of nutrition developed, home economists assumed much of the responsibility for its dissemination.

With the appearance on the market of new fabrics, other products made of

* Sidonie Gruenberg, *Your Child Today and Tomorrow* (J. R. Lippincott & Co., Philadelphia and London, 1913), p. 19.

new materials, laundering and cleansing substances and a variety of household appliances, home economists studied these products from the point of view of the user, both in order to give the home-maker sufficient knowledge to make good selections and to use and care for such products properly, and in order to advise producers on designs appropriate to home use. Industries soon began to employ home economists to demonstrate and sell their products as well as to aid in their production. Consumers organized to support testing agencies which could advise them on the comparative merits of competing items.

It was a small step from the selection of products for the home to concern over budgeting and the management of household finances. With increased numbers of women working, increased recreational attractions outside the home, and more leisure for the breadwinner to spend in the home or out, home management became a matter of the efficient use of time as well as money, and a considerable amount of research was carried on to determine how housewives actually performed their day-by-day tasks. These studies resulted in kitchens and home plans designed to save steps and efforts to bring to each of the household tasks the same kind of analysis and efficient arrangement as industry was applying to factory operations.

By the 1920s and 1930s findings in the fields of psychology and sociology began to be incorporated into home economics thinking and to shift the focus from the things used in the home to the people making up the family group. It was at this point that child-study became a central part of the home economics curriculum. Much attention was given to understanding the sociological changes which the modern family was undergoing and to redefining the roles of family members and the functions of the family group.

Largely for accidental reasons related to the establishment of colleges of agriculture in the United States, much of home economics came to be associated with agricultural education and advice. In Europe there were schools of agricultural domestic economy. Within the American agricultural extension service, home demonstration agents to aid and advise the farm woman on her home became the counterparts of the agronomists who advised the farmer on his crops, and similar services were provided elsewhere.

These services reached old-fashioned homes where food was raised and preserved and many productive household activities were carried on which were disappearing from city homes. Paradoxically, much of the energy of the home economics profession in the United States was devoted to the type of homemaking which was rapidly declining as the country became more urbanized year by year. But this very emphasis provided a basis for aid to underdeveloped areas, since many of the skills and techniques developed through rural extension programmes were helpful in the efforts of families in these predominantly rural regions to raise their levels of living. From the 1940s on, first in Latin America and then in other parts of the world, the field of home economics was one in which technical assistance was frequently sought and often effectively given. By the mid-1950s it was part of the agricultural exten-

sion programmes of most Latin American countries, Japan, Korea, the Philippines, India, Thailand, Iraq and Liberia.

Other developments brought home economics subjects into general education at elementary, secondary and university levels. Colleges and universities added home economics departments or faculties until the field became an expected part of a university programme. In contrast to the agricultural home demonstration programmes, these university programmes generally gave a central place to sociological and psychological materials, and they led the trend away from preoccupation with household activities in the direction of child development, family living and human relations.

Home economics spread to other countries from this source also. Notably in India, Pakistan and the Philippines, university programmes in home economics, developed with technical assistance, gave an important place to child development, and they incorporated materials from the social sciences as well as from such fields as nutrition.

III. AIDS IN CHILD REARING

The Soviet Union experimented extensively with the collective upbringing of children and the results of this experience were available to other communist countries. Israel, also, used collective upbringing in its communal *kibbutzim.*

In the principal children's establishments of the USSR—crèches for children under three and kindergartens for those from three to seven—education in children's groups carried on by specially trained staff was combined with home training. Children divided into age groups followed programmes of physical and mental activities based on the latest data supplied by pedagogical science and designed to develop a sense of comradeship, independence of character and a necessary sense of discipline. For children of school age responsible social activities in school and the Young Pioneer children's organization continued the process of character training. Close contact between crèche, kindergarten or school and the parents through parents' committees, lectures on questions of child rearing and parents' universities aimed to combine collective and home upbringing.

In the United States also it came to be recognized that many children growing up in small urban families needed opportunities not furnished by the home to develop patterns of social behaviour and to learn to establish social relationships with others of their own age, and these considerations led to the establishment of nursery schools to supplement the functions of the home. Such nursery schools had two distinct origins and served two groups of children. In many places they were primarily for children of working mothers and they came into being as extensions of day nurseries established by welfare agencies to provide places where infants could be left during working hours. Under the influence of a growing awareness of the needs of the child, many day nur-

series were converted from mere custodial institutions to nursery schools where trained workers used play techniques educationally to promote the child's development. At the other end of the scale, nursery schools were privately established in the United States and to some extent elsewhere by groups of families who were in a position to support such schools, sometimes co-operatively, for their own children.

In Europe kindergartens for children from three years up, often known as Froebel schools, were provided extensively by private and in some cases by public agencies. Day nurseries for the children of working mothers continued to be maintained by welfare organizations and by factories.

While the age at which children were enrolled in kindergartens varied and extended in some places to the age reserved for nursery schools in others, formal educational systems rarely included classes below the kindergarten level, and nursery schools remained an extension of the home rather than a part of early formal education. The nursery school movement spread in the 1920s and 1930s and continued to flourish thereafter. Home economics teachers recognized its value as a laboratory in which students could observe child behaviour and practise child care. By the 1940s no university home economics department in the United States considered itself complete without a nursery school, and nursery school laboratories were included in the university home economics programmes developed in the 1950s in India, Pakistan and other countries.

The importance of group association for the development of the child was also recognized since social participation in a small group offered the child means through which he might develop self-discipline and the ability to form new relationships, and had an important influence on the image of himself which he gradually built up. Conscious efforts were therefore made to provide opportunities for children to function in small groups—in nursery schools, in character-building organizations such as Boy Scouts and Girl Guides, settlement houses and youth groups.

In some countries the period of adolescence came to be recognized as a time when the child must make new emotional adjustments. Studies brought out the ambivalence of the adolescent in his struggle to achieve independence and the conflict between his impulse to resist parental supervision and authority and his need for parental reassurance and support. The desire to give the adolescent an opportunity to learn how to relate to members of the opposite sex was reflected in greater freedom of association between the sexes during adolescence than had usually been accepted in the past.

All these efforts to apply technical knowledge to the rearing of children and the functioning of family and home were designed not only to aid individual parents but as preventive measures against social breakdown. Evidence mounted that failure of the child to establish a meaningful relationship with parents or parent substitutes in infancy was basic to much later mental breakdown, juvenile delinquency, antisocial attitudes such as prejudice or sadism, and

sometimes to a low I.Q. and poor academic performance. It thus became socially important to foster favourable conditions for child development, and all manner of policies were guided by this consideration, such as the modification of procedures in some maternity hospitals in order to place the child in the room with the mother rather than in a separate room for infants, or the use of foster homes in preference to institutional care for children deprived of their own homes.

In industrially developing countries programmes relating to child rearing and to the home were of importance in view of the social changes taking place in these countries. The single family home, in the western sense, was a new institution in the areas where the joint family was beginning to give way. As the smaller family unit replaced the larger, it faced many new situations in establishing a different type of home. The centres which sought to make the fruits of scientific knowledge available to the home were part of the effort to facilitate this aspect of social change.

Comparative studies of child rearing in various cultures and their relation to the types of adult personality which these cultures tended to produce focused attention on the problem of what kinds of personalities can survive and flourish in modern society, and they raised the question as to whether current practices were well designed to produce individuals of such types. It began to appear doubtful whether persons who did not develop independence, the ability to make their own choices, and the capacity to tolerate the independence of others could be expected to function effectively under modern urban conditions and to make democratic institutions work. All this had a direct bearing on broad issues of economic and social development. For it called into question the idea that modern economic organization or democratic political institutions could be imposed by people on themselves, through the drafting of a plan or a constitution or the establishment of administrative procedures, without regard to the kinds of people their child-rearing systems were producing.

CHAPTER XVIII

THE ENVIRONMENT

In the twentieth century an ever-increasing proportion of the world's people lived in urban communities. The extraordinary expansion in the size and increase in the number of the world's cities was in fact a major twentieth-century phenomenon. Both the opportunities offered by modern urban living and the problems created by the concentration of population challenged the knowledge, ingenuity, and capacity for organization of social scientists, engineers, administrators and responsible citizens.

As cities grew in size and complexity, the disparity between their ways of life and traditional rural manners of living increased. But at the same time urban influences extended more and more widely, penetrating through many channels into rural communities to modify the outlook and habits and to break down the isolation of rural people.

I. CITIES

Cities were by no means exclusively the product of industrialization; they long had served, and continued to serve, as commercial or administrative centres. The cities which set their stamp upon the life of the period, however, were primarily those which accompanied the growth of industry and were made possible by industrial technology. In the western countries, the industrial city became the focus of economic life and the milieu which not only established the way of life of its residents but modified many aspects of rural living as well. In Asia, Africa and much of Latin America large cities oriented toward the economies of the industrialized countries developed as enclaves within, and sometimes detached from, their surrounding areas. With the political and economic reorientation of these areas, they became the centres of national life.

Both in the industrialized and non-industrialized countries it was the large, metropolitan centre that grew most spectacularly in the first half of the twentieth century. In 1900, 5·5 per cent of the world's population lived in cities of 100,000 or over; by 1950 the proportion had increased to 13·1 per cent. In absolute numbers the increase was from 89 to 314 million. More than 100 million people, amounting to 4 per cent of the world's population, lived in the forty-nine cities with over a million inhabitants. In 1900 there had been only eleven such cities. Great metropolises such as London, New York, Tokyo and Shanghai had five to eight million inhabitants. In a period of ten to fifteen years São Paulo, Brazil, increased 50 per cent, while Lima, Peru and Djakarta, Indonesia, tripled. Examples could be multiplied. The sheer size

of these mammoth cities required a very high degree of economic, political and social organization and the mobilization of immense physical resources to meet the daily needs of such large numbers of people. The development and maintenance of urban facilities and services on a mass scale was one of the major achievements of the age. At the same time the continual expansion of the great metropolitan cities constantly created new and difficult problems and often thwarted efforts to meet old ones.

Most of the industrial cities of the nineteenth century had experienced an uncontrolled and haphazard development. Industries dependent upon water power, steam and mechanical operations had drawn working populations and subsidiary or related industries to central locations where power was available. Private ownership of land, speculative building and the play of competitive forces had determined land use. With a few outstanding exceptions, such as the city of Amsterdam whose growth had been planned and controlled, it was only after severe congestion and insanitary conditions had developed that citizens and governments were aroused to action in the attempt to remedy existing evils and prevent their recurrence. In the face of continued growth such efforts often took the form of a rearguard struggle to prevent the situation from becoming worse. Newer industrial cities which grew up during the twentieth century rarely escaped some of these same difficulties in spite of measures for regulation and planning.

When industrial development began to reach the predominantly agricultural countries, especially after the second world war, the resulting urban growth had features which distinguished it from that of the older industrial areas. European and North American cities had grown through the pull of employment opportunities at a rate which corresponded more or less to the rate of industrial development, while empty lands overseas had offered an alternative recourse to Europe's excess peasant populations. Many Asian, Latin American and African cities, however, were filled with rural migrants who came to the city not only because there was employment for them, but often because they could not secure a livelihood from the land under existing conditions of land tenure and agricultural technology; some came as refugees from areas of political turmoil or banditry, or were lured by a vision of city life.

These cities had fewer resources with which to provide urban services than had European and American cities at any time. Yet the growth of population of the large cities of Asia from 1900 to 1950 amounted to 450 per cent as compared with 160 per cent for the large cities of Europe and America during the same period and the peak of 250 per cent for large cities in Europe from 1850 to 1900. Rates of growth in some of the large cities of the USSR and Africa were even higher.

Efforts to deal with the needs of various types of urban communities led to the development of a considerable body of systematic knowledge, tested experience and formulated principles derived chiefly from work in the western cities. At mid-century the booming cities of the newly industrializing countries

were becoming the object of joint study by technicians from older and newer industrial areas and the problems of urbanization in these regions were a focal point in the United Nations' study of the world social situation and an object of its technical assistance programme. Virtually everywhere, however, action fell short of established goals.

The major physical and social aspects of the large city involved: the basic physical necessities of water supply, disposal of wastes and transport facilities; housing; land use, both in the centre and on the fringes of the urban area; provision of services for the safety, order, welfare, education and cultural development of inhabitants; city administration; social organization and citizen responsibility.

1. *Physical facilities*

(*a*) *Water*. As soon as population reached a density which made private wells unsafe and insufficient, the need for water became acute. This involved two problems: finding and tapping adequate sources of supply, and such purification as might be necessary to protect the population from diseases carried by contaminated water such as cholera, typhoid and dysentery. Purification by means of filtration through sand or other substance had been introduced into the public water systems of a number of European and American cities during the nineteenth century. At the opening of the twentieth century, however, many of the large cities did not have safe water supplies and epidemics of water-borne diseases were frequent.

In the first quarter of the century vigorous public health efforts to eliminate epidemic diseases led most European and American cities to ensure the purity of their water supply. Chlorination, first used on a large scale to check a typhoid epidemic in Lincoln, England, in 1905, offered a cheap and effective method for treating even badly polluted water, and remained the most commonly used process, although other chemicals were employed in some water systems. By mid-century the need to ensure pure water had become so thoroughly accepted in North America, Britain and much of western Europe that supplies had generally been made safe in smaller towns as well as in large cities, and water-borne diseases had been eliminated in these urban areas. In most other places pure water remained a major city problem.

For many cities it was easier to meet the problem of purity than that of supply. As cities expanded they outgrew their sources of supply and reached far into their hinterlands, tapping lakes and damming streams as much as a hundred or more miles away. With rising living standards and the installation of modern plumbing, *per capita* consumption of water increased sharply, taxing still further the available supply. Large quantities of water were also required in the operations of many industries. *Per capita* consumption was less than 5 gallons a day in poor areas where supplies were short or had to be carried, about 20 gallons a day in small, non-industrial communities in

Britain or the United States, 50 gallons in large commercial British cities and 100–200 gallons in North American metropolitan centres.

By the middle of the twentieth century many cities were approaching the limit of their water resources with no new source available. In heavily urbanized regions such as the British Isles, north-eastern United States and western Europe, cities competed for remaining water resources or were unable to extend their range without running into some other city's source. The competition was especially acute in relatively arid areas. Some cities were forced to supplement their clear water from lakes or streams with polluted river water which could only be used after treatment and heavy chlorination. One of the few remaining untapped sources was the ocean. It appeared that the future of some of the major urban areas near the sea would depend on the success of the search for an economical method of removing the salt from sea water. Most of the Asian cities, except in Japan, had hardly begun to try to provide an adequate supply.

(*b*) *Disposal of waste*. The problems of waste disposal were only second in importance to those of water supply. Sewage systems of western countries used water to carry off the wastes either directly into a river, lake or the sea or through a treatment plant where bacterial action and sedimentation reduced and collected the solid matter, made it suitable for fertilizer and left the water relatively clean. Because of the high cost of installing and maintaining an adequate sewage treatment plant, many cities dumped untreated wastes into rivers or the sea, polluting sources of water supply for cities downstream or making beaches unfit for use.

Disposal of industrial wastes created a special problem, for these often consisted of noxious chemicals, gases or other dangerous or unpleasant substances which contaminated the atmosphere and seriously polluted the areas where they were dumped. City ordinances requiring the use of devices to minimize the amount of smoke released into the air helped to reduce the pall that hung over industrial cities, blackening the home and filling the lungs with soot. Yet Birmingham, England, which enacted its first smoke control regulation in 1817, was still struggling with the smoke problem in the 1950s.

The more serious problem of atmospheric pollution from gases released by factories and by heavy motor traffic in city streets also remained unsolved and the nature of the problem was insufficiently understood. From time to time the danger was dramatized by a disaster when a particular atmospheric condition prevented noxious gases from being carried away. Such disasters in the Meuse valley, France in 1930, Donora, Pennsylvania, USA in 1948 and Poza Rica, Mexico in 1950, made hundreds of persons ill and many died. Less dramatic episodes were reflected in irregularities in the mortality rates of London and other cities. But in spite of extensive research in several countries and various attempts at control, a number of industrial cities continued to be beset from time to time by smog or other forms of irritating fumes.

Chemical wastes from industry dumped into sewage disposal systems often

destroyed the bacteria on which the effectiveness of the system depended and made the solids which remained after treatment unsuitable for use as fertilizer. Chemical detergents which were increasingly used in place of soap also prevented the proper functioning of the systems. How to dispose of radioactive wastes from atomic installations was the latest and potentially the most serious of the disposal problems confronting industrial communities at the middle of the century.

Most Asian cities did not install water-borne sewage systems, or only provided such systems for a limited sector. They depended chiefly on the manual collection of night-soil, which in the case of China and Japan was the principal source of fertilizer and an essential element in the rural economy and rural–urban balance. In the groups of huts which formed the slums of Asian cities around the periphery and within the city area, lack of any satisfactory disposal system constituted a continual health menace. Construction of a sewer in Peking in the 1950s was of such importance as to be the theme of a play, *The Dragon Whisker Drain*, by one of China's leading writers, Lao Shê.

(*c*) *Transport*. Without adequate transport facilities no large city could function, for workers must reach their places of employment, and supplies essential for daily living must enter the city and be distributed to shops and homes. The paving and upkeep of streets was a prime charge on municipal budgets. Public transport was provided in every city by trams or buses and in most of the largest by some form of rapid transit, usually an underground or elevated electric railway. With the widespread use of automobiles, private motor transport supplemented public services and at times virtually supplanted them when it reduced the number of users of public transport below an economic level of operation.

The efficiency and cost of transport affected the shape of city growth, and this in turn brought additional transport needs. The industrial cities originally were centred around the source of power or the transport system upon which their economic activity depended, and their growth was governed by strong centripetal tendencies, as the advantages of being close to subsidiary industries reinforced the advantages of being close to power sources. With the development of electric power which freed industry from dependence on the mechanical transmission of power from its source, of telephone communication which made proximity not necessary for communication, and of motor transport which freed both goods and workers from dependence on rail or water transport, the strength of these centripetal tendencies was weakened. The costs and inconveniences of central location—especially high land values and the traffic congestion which choked the streets—exerted a counter-push toward the outskirts.

The spreading suburbs where families moved to enjoy space and single-family dwellings added to the problem of transport as increasing numbers of commuters travelled long distances and often encountered traffic delays between home and work. Streams of cars became a constant menace to life and

limb. Cities undertook exhaustive studies of traffic patterns, established elaborate systems of traffic control, and adopted a variety of devices such as one-way streets, express highways into and around cities and exclusion of through-traffic from residential areas. In spite of all efforts, however, traffic congestion continued to grow. At mid-century no major city had as yet solved its traffic problems or found a means to prevent them from becoming worse. (Pl. 17a, 17b, 18.)

2. *Housing*

In nearly all parts of the world in the twentieth century large proportions of the urban population were housed below accepted standards of health, safety and decency. The industrial cities of Europe and America inherited a grave problem of bad and insufficient housing from the process of rapid industrialization and urban growth which took place during the nineteenth century. Other countries developed the same problem in an even more acute form as they later experienced the same process. The problem was complicated by the financial need to spread the cost of a building over the years of its use, and by questions of legal rights and economic valuation of urban land. It was intensified as rising standards of what constituted a decent and sanitary home for a worker's family called for the provision of more ample and costly dwellings and made even less tolerable the old type of dark cramped quarters.

First in Europe, then in North America and the USSR, and finally in the developing areas of Latin America, Asia and Africa, governments intervened to attempt to meet the housing needs of their working populations. By the latter half of the nineteenth century it had already become apparent that they could not ignore the dangers to health and safety which the worst of their city housing offered. Public health reports in Britain, the United States and elsewhere had brought to public attention the insanitary conditions of the typical workers' quarters where a single room constituted a home, ventilation and sunlight were often lacking and beds were frequently used successively by workers on day and night shifts. Before the close of the century regulatory laws had been passed in a number of countries, including Britain, the Scandinavian countries, Germany and several of the states in the USA.

These laws introduced the concept which provided the definition of the housing problem and the dynamic for efforts to deal with it in the succeeding years—the concept of minimum standards for decent, safe and sanitary housing which it was a public responsibility to maintain. They provided for minimum standards of safety in the use of building materials, for sanitary inspection, for the right of municipalities to require landlords to repair or destroy grossly dangerous or unsuitable structures, and in some cases for excluding from residential neighbourhoods industries whose wastes polluted the surroundings.

Regulatory measures became more widespread and were greatly elaborated in the course of the twentieth century but they did nothing to stimulate the

building of new homes within the reach of workers' incomes, and thus left the basic problem of housing shortage unmet. In fact the higher standards which they required made it increasingly difficult to build dwellings which workers could afford. Moreover, so long as a shortage of decent housing existed, condemnation and destruction of slum dwellings merely pushed families into other already overcrowded or deteriorated areas.

In the early years of the twentieth century civic leaders in Europe perceived that positive steps to facilitate housing construction and to lower housing costs would have to be taken. Denmark in 1887 and Sweden, Belgium and Great Britain in the 1890s had paved the way with government aid in the form of cheap loans to co-operative building societies and other forms of government assistance to builders of low-cost housing, and some housing construction by local government had been undertaken. The Dutch in 1901 enacted comprehensive legislation for housing and town planning which was still a model for such legislation fifty years later. Prior to the first world war, some large-scale projects for middle-income families in European cities were constructed with government aid by co-operatives and other non-profit organizations, and some encouragement to the building of workers' homes was provided by other forms of public contribution. These measures were, however, limited and scattered. In Great Britain less than 10 per cent of the local authorities took advantage of the cheap loans for municipal housing or the power to acquire land on advantageous terms for workers' housing which had been authorized by law.

In the decade following the first world war European governments stepped up their housing activity sharply in an attempt to remedy the shortage which lack of home building during the war had made much worse, and to close the gap between the cost of housing and the rents which workers could afford to pay. Large numbers of workers' homes were built by local authorities, and more extensive assistance was offered to co-operatives, non-profit corporations and individuals in such forms as loans, subsidies, the provision of municipal land and relief from taxes.

By such means some 4,000,000 workers' dwellings were constructed in Europe before these efforts were brought to a halt by the economic depression, the rise of the Nazis to power in Germany and Austria, and the shift of the European economies to a war basis. The workers' houses built during these years with one or another form of public aid housed from 10 to 22 per cent of the populations of the cities where such construction was undertaken.

The houses or flats thus provided often permitted a radical change in the living standards of workers. The new quarters met and even exceeded minimum standards of space, ventilation, light and sanitation, they were located away from the danger, noise and fumes of traffic arteries and industrial plants, and they were commonly provided with play space for children and community facilities for adults. They expressed the growing conception of the worker as a citizen entitled to a decent way of life, and they expanded the community's expectation as to what urban living could and should offer.

Yet notable though this achievement was, it left the European housing problem basically unsolved and in most countries failed to prevent the situation from deteriorating. New migrants continued to enter the cities and new urban families to be formed faster than new homes were built. The UN Economic Commission for Europe estimated that on the eve of the second world war there had been an accumulated deficit of over 12,000,000 houses. It noted that in the inter-war years 'Europe never built enough housing for the current needs of new families and for the replacement of dwellings obsolete because of age' and that 'slum conditions and community blight were . . . growing worse and more widespread'.*

The USA and Canada did not accept the construction of sufficient housing as a public responsibility until long after the principle had been well established in other industrialized countries, though their municipalities and states had enacted regulatory measures, and the control of neighbourhoods by means of zoning had become widespread after its introduction in 1916. The need seemed less apparent in these countries where real estate was a favourite form of speculative investment for people of small means as well as large, confidence in private enterprise was strong, and the worst slums were generally occupied by the latest immigrants who moved to better quarters after a few years. Not until the 1930s did the United States embark on a programme to facilitate the financing of private building by means of government mortgage insurance and loans, and to provide subsidized public housing for low-income families to replace their slum homes.

Soviet Russia recognized housing as a problem of critical importance and included measures to deal with it at each stage of national development. The first step, immediately after the October revolution, was to make sure that existing housing was fully used. Housing for rent and large mansions were nationalized and all space not fully occupied was used for the homeless and those housed in cellars or other unsuitable shelter. During the following decade a considerable volume of housing was built or made more habitable, some by government building some by state-aided co-operative societies. The rate of building in these years was, however, limited by the inefficiency of the building industry, material shortages and the concentration of effort on the development of heavy industry.

In the series of five-year plans from 1928 on, housing received a significant and growing place. The first five-year plan called for more than a doubling of the public investment in housing and for measures to begin to modernize the building industry. Each of the succeeding plans provided for a sharp increase in volume. On the eve of the second world war the total supply of housing had been increased by some 40 per cent since the mid-1920s. Nevertheless, the concentration of productive resources on basic industrial development under these plans entailed certain sacrifices in consumption, and housing

* UN Economic Commission for Europe, *The European Housing Problem—A Preliminary Review* (UN, E/ECE.110, 1 October, 1949).

competed directly with heavy industry for materials and workers. The gap was therefore not bridged between the supply of housing and the size of the urban population, which more than doubled during these years. Though the quality of much workers' housing was improved by more modern construction, homelessness was eliminated and tenants were protected in their occupancy, the rationed space enjoyed by most workers remained below the accepted sanitary housing standards.

At the close of the second world war it was apparent that far more drastic measures than had hitherto been contemplated by even the most ambitious of the European governments would be necessary to reconstruct the devastated areas, keep pace with growing demands and make a dent on the backlog of accumulated deficiency. The Economic Commission for Europe noted that even if pre-war rates of housing construction were doubled, it would take an average of twenty-two years for the European countries to come abreast of their housing needs. It was apparent too that home building for low-income urban families had ceased to attract profit-making private investment, since current building costs would require prohibitive rents, equal to about a third of a European worker's income. The European governments accordingly expanded their programmes of construction or financial aid as fast as their financial resources permitted.

The British followed the system of municipally constructed housing for all except upper-income families while the Scandinavian pattern was to provide government aid to co-operative, trade union or other non-speculative groups, sometimes including a rent subsidy for the benefit of lower-income families. Dutch housing followed both systems. Though in most countries legislation continued to provide encouragement to private builders, the great bulk of European home building for urban workers in the decade after the second world war was by public authorities or by non-profit agencies under government supervision. In spite of these enlarged efforts, however, most countries failed to keep pace with the current needs of their growing populations and deficits continued to increase.

In the United States a high level of general prosperity and generous public assistance in such forms as mortage insurance, loans to war veterans, and other special aids stimulated widespread private building activity, especially in the suburban areas surrounding all major cities. The result was to meet a much larger proportion of the desire for home ownership than had been met there or elsewhere in the past. New housing, however, still was beyond the reach of many low-income families. Public housing programmes were small and were limited to families whose incomes were well below the level for which private interests could be expected to build decent homes at current costs. Numbers of urban families continued to exist in crowded dilapidated slums, particularly those whose inability to find and afford suitable accommodation was intensified by size of family, instability of employment or racial discrimination; some were reluctant to leave familiar surroundings for a new environment.

When Canada enacted national housing legislation in 1954, the range of methods which it provided reflected the accumulated experience of other countries. These included: government provision of insurance for mortgage loans and loans for home improvement; guarantee of a minimum income from rent to builders of certain types of rental housing; low-interest housing loans from public or other regulated sources to municipalities, co-operatives or other non-speculative groups; public construction of housing; rent subsidies for low-income families; and grants to municipalities for slum clearance and the redevelopment of urban areas.

The USSR, with a third of its already insufficient urban dwellings destroyed by war, made a drastic effort to replace the loss and to catch up with mounting needs. Even during the war the government carried on a large-scale building programme to provide housing for the populations evacuated to the east and other workers in the new industrial cities beyond the Urals, and for the restoration of shelter in the western areas as rapidly as they were liberated. A central state committee on architecture was established in 1943 to supervise and co-ordinate the rehousing programme and special factories were set up for the mass manufacture of standardized houses and other building materials. In the 1946–50 five-year plan for the rehabilitation and development of the national economy, housing was assigned 14·5 per cent of total capital investment as compared with 10·5 per cent under the last pre-war plan. In accordance with this schedule the loss through wartime destruction was more than made up in urban areas, but the growth in urban population of some 30 per cent in the 1940–50 decade kept ahead of the rate of new construction. The succeeding five-year plan attempted to produce housing faster than the rate of urban population growth by raising the output and lowering the costs of the construction industry through mechanization and the development of new materials, designs and methods of assembly, and by seeking devices for carrying on construction during the winter. After 1955 the rate of housing construction rose very sharply, reaching more than double the 1955 volume by 1958.[1]

As the underdeveloped areas plunged into the process of accelerated industrialization after the second world war, all the housing problems which had beset the industrialized countries burst upon them in exaggerated form. Levels of income were lower in relation to the cost of building than they had been at any time in Europe or America. The numbers involved and the rate of urban growth exceeded those with which most of the older industrial cities had had to deal at any one time. A larger proportion of the total population was unable to secure or afford decent accommodation; in major Indian cities, for example, not only the vast majority of the working class but 50 per cent of the middle-class families lived in single rooms. Capital resources, building materials and skills were extremely scarce. At the same time the public conscience was already aroused against conditions which earlier generations would have accepted as the natural lot of the poor.

In the face of overwhelming odds governments in Latin America, Asia and Africa set up special agencies and cast about for new solutions beyond those which European countries had tried. They first followed the European lead in undertaking construction by public agencies or through publicly established mortgage banks. Some programmes were of spectacular size, such as a Bombay development housing 20,000 people where a few months before there had been only mud flats. But even these barely touched the need of a growing city like Bombay, where at least 2,000,000 of its 3,000,000 inhabitants slept in one-room airless *chawls* or under low shelters made of scraps of cardboard, sacking and tin, or on the pavement. In most of the underdeveloped countries government-built housing was occupied by government workers or other middle-class families with sufficient income to pay an economic rent. Few governments were able to provide the subsidies which would have been required to enable the vast majority of urban workers to enjoy decent housing.

In the search for less costly ways to meet the most essential needs governments devised various means to utilize the occupant's own labour to build his shelter, especially in tropical areas where less substantial construction would provide more adequate shelter than in colder climates. Around the fringes of Latin American and Asian cities, squatters built shacks on hillsides, in gullies, along roadsides, in fields. Often they occupied public land from which it was difficult to evict those who had nowhere else to go. 'Pirate' suburbs sprang up overnight beyond the limits set for the extension of water, sewage and roads.

Unable to prevent this growth, governments attempted to give it shape by setting aside land equipped with minimum facilities, where families were permitted to construct their homes. The most elaborate of these 'land and utilities' projects consisted of individual water and sanitary units and cement floors, spaced on small plots; others provided central water, sanitary and laundry facilities for a group of plots where houses could be put up; some offered only streets, a public source of water and materials for sanitary latrines. Some urban communities adapted from rural areas programmes of 'aided self-help' housing whereby groups of families, organized to work co-operatively, joined in the building of each others' houses under the guidance of a public agency which supplied plans, instructions for the making of building blocks and other materials, and technical supervision of the project. Such plans, which originated for rural housing in the Caribbean area and were developed for large-scale urban housing in Chile, were taken up in a number of regions, including other Latin American countries. They generally included a system of loans or subsidies to enable the occupants to purchase the materials, as well as municipal provision of water, sewage and electricity.

While these programmes were welcomed, not only because they offered a practical approach to certain types of housing but because of the education and the stimulus to responsible effort and co-operation which they provided, they could not offer even a remote solution to the housing problem in cities such as Singapore, where the official standard of overcrowding was defined as five or

more persons per room, or Hong Kong, where housing for Chinese refugees took the form of one-room dwellings in six-storey buildings, with an average of five 'persons' per room—children counted as ½ person—and a population density of 2,500–3,000 persons per acre.

In the effort to break out of the vicious housing circle in which both the industrialized and industrializing countries were caught, attention was directed to improvement in methods of home building. The Economic Commission for Europe noted in 1951 that the costs of building were a cause of concern, since in most countries there was no evidence of a significant increase in the productivity of the building industry.

During the twentieth century the building industry everywhere lagged behind other industries in technological development; it lacked the organization or orientation to engage in the kind of research that brought revolutionary advances in other fields, and the cost of housing in consequence remained high relative to workers' wages and the prices of other products. An indication of the meaning of this difference in technological development may be seen in the comparison of the automobile and building industries in the United States. Although the building industry of that country was one of the most mechanized and highly developed in the world, it was estimated that, if a 1950 American automobile costing $1,700 had been made with as little change in technology since 1910 as the building industry had shown in those forty years, the car would have cost $60,000.

Such a comparison gives an exaggerated view, for the production of housing differs in its nature from that of automobiles, and it was relatively more advanced in 1910. But factors limiting progress in building were real. Specialization of function in the building industry continued to be based on a series of independent craft activities which had to be co-ordinated rather than on a division of labour within a single process, as in factory production. The economic possibilities of mechanization, standardization of parts, factory production and the reorganization of construction methods were often resisted or ignored by tightly organized building labour, jealous of its craft prerogatives, by architects and engineers trained to design and plan in terms of existing techniques, and by builders who were often small local entrepreneurs.

The need for basic and systematic research was recognized by the British after the first world war, but their building research station, established in 1921, remained the only such national research organization until the second world war, when one European country after another began to establish national building research organizations. An International Council for Building Research and Documentation was formed at the initiative of the United Nations Economic Commission for Europe in 1949 and some forty national organizations, public and private, became members when it held its first general assembly in 1953.

Efforts to bring some of the economies of organized mass production into the building industry took two forms: factory prefabrication of parts of houses,

to be assembled on the site; and application of the principles of assembly-line production to the building process at the site itself.

Prefabrication of frame structures was developed in the early years of the century in areas, especially North America, where wood was a common building material, but these proved suitable primarily for small buildings, warm climates and temporary use. In the inter-war period considerable experimentation was carried on by manufacturers in the use of new and lighter materials such as aluminium sheathing or composition board and with new methods of insulation. After the second world war the USSR concentrated on the development of prefabricated wall panels, roofs, floors and other structures of reinforced concrete in its determined effort to mechanize its construction industry, and experiments along similar lines with special types of concrete and other materials continued in other countries.

Mass-assembly at the site itself was more widespread than factory prefabrication, except in the Soviet Union, and more successful in holding down costs; in the United States it brought a high degree of rationalization into the building of large housing projects. Where a large number of houses or blocks of apartments were built simultaneously, the project was set up as a single operation, with materials delivered or produced on the site and crews of workers executing successive parts of the job with the timing and precision of a factory assembly line. Economies of such site-assembly methods were increased by the development of standard units which could be used flexibly in different multiples and combinations in designing the house, and which could be fabricated on a mass-production basis.

Further efforts to reduce building costs, especially in the industrially underdeveloped countries, took the form of experiments with the use of low-cost local building materials, such as various forms of stabilized earth, tile or treated bamboo. Where space and transport facilities permitted the building of small houses rather than multi-storey apartments, economical construction of this sort offered a possibility for improving the living conditions of the pavement dwellers and the residents of shacks or cubicles without involving costs which neither the occupants nor the municipalities could afford.

In spite of widespread efforts to meet the urban housing problem there remained a paucity of knowledge as to the actual needs and desires of families of different types in varying circumstances and cultural settings. Some types of city dwellers, moreover, were persistently overlooked, notably the large numbers of persons who were permanently or temporarily unattached, and the special needs of others, such as old people, were only beginning to be considered in the planning and construction of housing facilities.

Although the most distinctive architectural school of the twentieth century, the functionalists, insisted that the house should be designed as a 'machine for living', systematic studies of family living in relation to housing design were few. An international review of such research up to 1953* found some limited

* United Nations, *Housing and Town and Country Planning Bulletin*, no. 8 (1953).

studies being carried on in the Scandinavian countries, the Netherlands, Britain and the United States; only occasionally, notably in Norway and the United States, were the results of such research used to introduce changes in design and then to study the effects of such changes systematically. The volume of research into social aspects of housing was however growing. In the Latin American countries it received special impetus from the work of the Inter-American Housing Center located in Bogotá, Colombia.

A guide to needed research provided by one of the leading experts in the field of housing in 1953 listed a few of the unanswered social questions in housing and town planning as follows:

(1) the effect of the kind of urban environment being produced, or capable of being produced, on social organizations, human relations and emerging trends in social values and attitudes;
(2) what people would want if they knew the full range of possibilities and all the practical limitations, and how such knowledge could be conveyed and desires expressed;
(3) why people move and how their habits are affected by change from old to new environments;
(4) whether the desire for home ownership is a desire for ownership *per se*, or for an opportunity to live at ground level;
(5) what are the effects of various policies for selecting tenants for large housing projects and of the relation between manager and tenants;
(6) what are the relative advantages of apartments which can be provided, as in Sweden, with services to aid housewife and children, as against the single-family house and garden which is the basis for housing developments in Britain;
(7) in designing houses, what is the comparative importance of space and equipment, and how is the appropriate design affected by the available community facilities; how in fact have the facilities which have been supplied in housing developments been used;
(8) what is the social effect of segregating groups of families on the basis of economic level, size, type, age-group or ethnic identity, as a result of the cost or design of buildings or selection of occupants, as against housing designed to bring into the same neighbourhood a mixture of families of different types and circumstances;
(9) who uses neighbourhood and who central city facilities, and in what respects is the neighbourhood principle a valid conception for planning; in the light of high rates of mobility, should the attempt be made to create environments which will induce people to settle down;
(10) what variety of homes are needed by different kinds of households; are housing standards too low or too rigid?*

* Catherine Bauer, 'Social Questions in Housing and Community Planning', *Journal of Social Issues*, vol. vii, nos. 1 and 2 (1951).

Although, as this partial list of unanswered questions revealed, much was yet to be learned with respect to the social aspects of urban housing, it was beginning to be recognized that urban housing involved not merely financial and physical problems but the social structure of city life, and that this aspect required as systematic study as the techniques of construction. The author of the above list of questions concluded by noting: 'What we failed to recognize was that the powerful tools employed for civic development and home production *also* predetermine social structure to such an extent that there is little room left for free personal choice or flexible adjustment' and that 'the most hopeful and ingenious innovations have often been wasted, because no one tested them to see how they really worked'.

It was indicative of the growing awareness of these social implications that the Inter-American Housing Center, established under the technical assistance programme of the Organization of American States at Bogotá in 1951, included social workers as well as engineers, architects and lawyers in its group of trainees from the housing administrations of the Latin American countries, and that these specialists studied and worked as a team on the critical housing problems of their region.

3. *Land use and city planning*

The uses to which urban land was put determined the location and type of housing, the character of neighbourhoods, the shape of the city and the pattern of physical growth. Control over urban land use was the principal device by which attempts were made to guide these developments in the public interest. In the course of the twentieth century restrictions were placed in most large communities on such use, and many cities adopted positive plans and programmes for the development of sectors of the city or the entire area.

Within whatever limits were set by national or local measures for control, cities tended to follow a common pattern of development. Industry and commerce crowded toward the centre in order to take advantage of convenience, transport facilities, labour supply and, until electricity became general, sources of power. Factories clustered around rail and water termini, or formed industrial nuclei, or satellite towns on the periphery. Residential sections ringed the central district or occupied higher ground above a waterside rail and dock area.

As the city grew, business and industry pressed outward against the residential area, and rising land values and changing neighbourhoods drove occupants to seek pleasanter surroundings further out. A new residential area was constructed while part of the old was replaced by business and the rest became a slum where old single-family homes were cut up, room by room, into quarters for workers' families, or were replaced by tenement houses into which workers' families were tightly packed. As the city continued to grow, new residential sections repeated the fate of the old, when industry, business and slums penetrated into these districts.

With the coming of rapid transit systems and then the motor car to link people with their places of work, the city spread its suburbs farther and farther into the surrounding countryside. In time some of the central slum areas began to be reclaimed and reconstructed, chiefly with high-rent, multi-storey apartments for those who could afford to shorten the long journey to work and did not feel the need of the space and greenery which suburban living offered. Slum dwellers displaced in this process either crowded into the remaining central slums or took the opposite course to the extreme fringe where land values had not yet risen so high as to be completely out of their reach and where they often formed colonies of squatters, shack-towns or edge-of-town slums.

Meantime, suburbia continued to grow and to widen—in fingers along traffic arteries and rapid-transit routes, in spotty developments where a land-owner chose to build a group of houses on his farm or home site, by incorporating into the metropolitan community what had once been neighbouring villages or towns, or in a solid front that spread the city circumference to wider and wider limits. The suburban sprawl produced growing traffic congestion as more and more thousands travelled daily between centrally located places of work and suburban homes. Commercial establishments set up branches in outlying areas, large suburban shopping centres began to draw trade from centrally located stores, central land values declined and the city found itself with a spreading fringe and decaying core. Around the outskirts was a sort of no-man's-land between city and country. Farms went out of cultivation as speculators bought up land ahead of the city's advance or rising land values brought taxes that farmers could not pay. Until the spreading city encompassed the area, land was often left untended, covered with squatters' shacks, spottily developed with isolated suburban units, scarred by roads and dumps and continually in a process of transition. (Pl. 19a, 19b.)

The nature of measures to control or guide this urban growth differed according to historic circumstances and urban traditions in different parts of the world. Those cities of northern Europe that had a tradition of strong local government, civic pride and orderly control frequently dating from the Middle Ages, and which often owned much of the surrounding land, never experienced the chaotic growth or faced the necessity for drastic remedial action comparable to that faced by cities in many other regions. As the impact of industrialization brought new problems, these cities adopted measures designed to permit orderly development. Sweden in 1874 enacted a law requiring every city to have plans regulating the layout of residential sections as well as streets, market places and public squares. Frankfurt, Germany, in 1891 introduced the idea of zoning. The Dutch housing and town planning legislation of 1901 included comprehensive provisions for the control of land use.

In Britain and North America on the other hand, and in much of the rest of Europe, industrial cities grew up in a climate of *laissez-faire*. Here private landowners determined the use to which urban land would be put during the

period of the city's growth. Decisions as to what to build and where were dictated by the entrepreneurial decisions of individual owners, real estate dealers and speculative builders. Municipal improvements, such as streets and public utilities, followed where profit-seeking enterprise led. Once these had been laid out, the pattern of the city was more or less fixed, and replanning of built-up areas became difficult or impossible. (Pl. 45a.)

The British were the first to seek to apply social remedies to the conditions created by uncontrolled urban growth. By the middle of the nineteenth century their major industrial cities, such as Birmingham, were already awakening to the fact that their open spaces had disappeared. In the 1870s British municipalities received authority from Parliament to condemn buildings which constituted a menace to health and to require their improvement or destruction. This was the first attack on the worst of the urban slums. Building regulations also limited the kinds of construction permitted in certain areas. American cities began to follow suit, including in their regulations limits on the proportion of an urban lot which could be covered by a residential building. By the end of the nineteenth century the principle was becoming clearly established that owners of urban land could use their property only within limits set by the public interest.

Elsewhere other traditional approaches to city development prevailed. The cities of Latin America, laid out in the manner prescribed by royal order in the sixteenth century, preserved and beautified their central plazas and frequently repeated the pattern with smaller plazas in other parts of the city. For the rest their growth was unsystematic and uncontrolled. France too had a tradition of central beautification dating from the mid-nineteenth century when Napoleon III commissioned Georges Haussmann (1809–91) to open up the heart of Paris. Other cities such as Vienna, Brussels and Berlin followed the example of Paris by cutting wide boulevards through congested slums and adorning the centre of the city with parks. Apart from these measures, France, Italy and other parts of southern and eastern Europe adopted neither the orderly development established in Sweden and Holland nor the remedial approach of Britain. Asian cities were generally a compound of palaces, temples or gardens laid out by and for past rulers, adaptations of European standards introduced by colonial powers into areas occupied by Europeans, and unlimited land coverage with intense crowding in the rest of the city.

The USSR substituted for the pattern of unregulated growth in tsarist Russia the planned development of new towns and the replanning of old cities. Here and in the other communist countries state ownership of land and central control of financial resources made it possible to approach these problems with less regard for the relation between the cost of supplying housing and the ability of the tenants to pay, and without the need to deal with private owners of the land. Housing was generally regarded as one of the public social services and the policy was to make living quarters available to workers at costs of no more than 5 per cent of their earnings.

In the course of the twentieth century regulation of urban land use was greatly extended in all countries and a common set of devices were applied, with differences arising from historic patterns of landholding and forms of control. In countries where landholding had been widely dispersed in small units, such as France, Belgium and the USA, a strong feeling that individual ownership was in the public interest tended to keep public intervention to a minimum. Where landholding had historically been concentrated, as in the United Kingdom, there was greater readiness to regard land as affected with a public interest and to accept broad measures governing its use. In Russia the complete absence of control prior to the first world war was replaced by the elimination of all private ownership of urban land under the Soviet régime.

Though countries differed in the manner in which they compensated owners for the loss of property rights, the general trend was to follow the distinction explicitly stated for Great Britain by Mr Justice Uthwatt in the report on which the comprehensive Town and Country Planning Act of 1944 was based.* Where the state actually took property, it would have to pay compensation to the owner since the state had no right to requisition property without compensation. Where the state by regulation limited the use which an owner could make of his property, it would be under no obligation to pay compensation although the owner might suffer a financial loss, since the right to use the property in the prohibited manner was not taken over by the state but destroyed as contrary to the public interest.

The use of building regulations which specified minimum standards of construction for buildings in certain areas, one of the oldest methods of controlling land development, was widespread and the scope of such regulations was enlarged. Building codes were usually adopted city by city, though in some countries such as Japan they were enacted on a national basis. Although building codes were necessary as defensive measures against unsafe construction, they sometimes had the effect of delaying technological development and the use of new materials, they tended to increase building costs and at best they served only to prevent the worst uses of land under regulation.

Broader control was provided by means of zoning, which designated certain areas as residential, commercial or industrial and specified the types of housing, e.g. single- or multi-family dwellings, and kinds of business or industrial activity permitted within them, as well as such matters as height of buildings and percentage of land to be covered. Zoning ordinances were adopted by German cities at the end of the nineteenth century and became the most widely used device in the United States and Canada after 1916. Similar results were obtained by town planning laws in some European countries. Zoning was only beginning to be adopted by the Latin American cities toward the middle of the twentieth century.

While zoning regulations provided an indispensable tool to prevent the

* *Final Report: Expert Committee on Compensation and Betterment* (H.M. Stationery Office, London, 1942), pp. 19–20.

further misuse of land, they could not undo the damage already done since they only applied to future construction and use. Moreover, zoning of specific neighbourhoods in a piecemeal fashion might not result in an orderly pattern unless it was combined with some procedure for the overall planning of the entire city. This was evidenced in the spotty development of many of 2,000 or more towns and cities in the United States which employed the zoning device.

The regulation of land subdivision on the outskirts of cities became increasingly important as cities spread outward and the suburban population grew. Many countries adopted regulations requiring the approval of plans for new subdivisions before the owner or builder was authorized to proceed with construction. Such plans prescribed the layout of streets and open spaces, access to through traffic and protection from it, the location and types of utilities, houses, shopping centres and public buildings. Subdivision regulation was often seriously hampered, however, by the fact that many cities lacked jurisdiction over land outside their municipal limits to which the city population was spreading. In 1953 one-third of the population of metropolitan Toronto, Canada, for example, lived in suburbs beyond the Toronto municipal limits. As in the case of zoning, moreover, subdivision control gave effective direction to city growth only where it was combined with overall planning.

Measures to clear away slums, particularly those located near the heart of the city, were undertaken by many European cities in the first quarter of the twentieth century, in the United States in the 1930s and in other countries after the second world war. Such measures generally took the form of the acquisition of slum land by the municipality, destruction of existing dwellings and the rebuilding of the area by public effort or its dedication to parks or other public uses. Slum clearance too encountered basic difficulties. The high value of the land occupied by slums, the cost of new building and the reduction of population in overcrowded areas made it impossible for most of the original slum dwellers to return to the area unless aided by rent subsidies. Slum clearance projects were costly to the government, although there was good evidence in many places that the costs would more than be made up in reduced requirements for police, fire, hospital and other expenses arising from the crowded, unhealthy and disorganized life of the slums. As displaced families moved into other sections of the city, the clearing of one slum area only worsened the conditions in others. So long as the basic problem of providing enough housing for the growing population remained unsolved, slum clearance was only a rearguard action against urban blight.

Acquisition by municipalities of vacant land, and control over the time and manner of its use, came to be the most important aspect of the land-use policy of many of the countries which had gone farthest in the effort to guide and control city growth. The city of Stockholm, Sweden, for example, began to acquire large tracts of lands both within and outside the city in 1904 and by 1950 owned more than half of the land within the city limits and an almost equal amount outside. Land reserves were acquired by municipalities to be

used at the time and in the manner called for by an overall city plan in a number of countries, including the Scandinavian countries, Britain, Germany, Austria, Turkey and some countries of Latin America.

Cities in several countries adopted a variety of other devices, such as differential taxation to penalize or encourage the use of land for particular purposes, rent controls, various measures to reduce the value of centrally located land and make possible its less dense use, and reparcelling of land where ownership patterns interfered with sound development.

In the years after the second world war it appeared that all these piecemeal efforts would not rescue the decayed centres of the overgrown cities. Broad plans for the redevelopment of whole sections of cities were undertaken, with enabling legislation permitting municipalities to acquire land, lower its appraised value, demolish existing structures and replan and reconstruct the area, aided in some cases by national subsidies. Such programmes for urban redevelopment were put into effect in the rebuilding of British and continental European cities shattered during the second world war, as well as in undamaged cities of the United States, Canada and some parts of Latin America. But urban redevelopment too came up against the continuing shortage of decent housing for ever-growing city populations and plans were repeatedly thwarted by the unsolved problem of where families could go who were displaced in the process. Where speedy reconstruction or the need to keep down costs were major considerations, moreover, the advantage of using existing utilities and streets laid out according to old patterns hampered the more rational use of space.

Attempts to create communities in the outlying areas which would provide the conditions for healthy and satisfying living dated from the opening of the century, when the garden city movement, launched by Ebenezer Howard (1850–1928) in 1898 (*Tomorrow: A Peaceful Path to Real Reform*), led to the building of Britain's first garden city, Letchworth, in 1903. While Howard's idea had been to divert population from large urban centres by creating new, self-contained communities of some 30,000 people, garden cities became in fact dormitory suburbs. In other countries planning of garden suburbs became part of the general city plan, as in Sweden, where residential communities situated at the stations on the suburban railway were carefully planned to contain a balanced supply of different types of housing, shops, schools and other facilities, and a layout which offered convenience, safety from traffic and access to green areas.

Overall planning for the development of the total city spread during the twentieth century from the well-ordered cities of northern Europe to many parts of the world. Britain adopted its first Town Planning Act in 1909. The first official city plan in the United States was prepared by the city of Hartford, Connecticut in 1907, and twenty years later city planning commissions were at work in some 400 United States communities. The broad-gauged Moscow city plan of 1936 greatly stimulated the planning and replanning of Russian

cities; the second five-year plan called for the reconstruction of some 400 cities, and the city plans developed as part of this programme later provided the basis for rebuilding many cities destroyed during the second world war. In 1937 Germany set up machinery for the general planning of towns. The establishment in that year of the International Federation for Housing and Town Planning with headquarters at The Hague evidenced the widespread interest in the field.

The scope of most of the city planning bodies was first confined to the layout of roads, streets and parks and the placing of public buildings and utilities. In some countries or communities planning was still in this stage at the middle of the century. Most planning bodies, however, extended their scope to include the location of residential, industrial and commercial activities and the provision of community services.

Initially planning agencies tended to prepare master plans with the idea that these would serve as a permanent guide to the city's development. But constantly changing conditions made it apparent that planning would have to be a continuous process of evaluation and re-evaluation and that the function of the body entrusted with the task must be to offer continuous leadership rather than a single proposal. Furthermore, the complexity of the task, the variety of factors and interests needing to be considered and the dependence of any plan for its execution on co-operation or acquiescence by the public led to the establishment of advisory bodies and the participation of professional and civic groups in the planning process.

Where, as was usually the case, the local municipality was the planning unit, the need to plan for territory outside the city limits led to a partial breakdown of planning efforts in some places, co-operative planning by adjacent jurisdictions in others, and in some to the intervention of the national government. By the middle of the twentieth century sufficient powers had been created by law in most countries to permit cities to carry out their plans. But here again practical difficulties arising from the growth of the urban population repeatedly prevented execution.

At the heart of the city planning process lay two closely related issues which remained unresolved up to the middle of the twentieth century: whether to allow high density of land use by constructing multi-storey apartment buildings or to spread out the population more thinly in single-family homes; and whether to plan for an ever-expanding metropolis or to use the tools of planning and control to develop a multitude of smaller cities rather than a few gigantic metropolitan areas.

The issue of low-density versus apartment building arose out of the differing practices in Britain and on the European continent, and alternate conceptions of the desirable use of space. As British towns grew they spread out over wide areas, and even the poorest housing was generally at ground level with some space for a garden. The principles laid down by British planners, who considered private space for the family outside the dwelling as an essential part of

satisfactory housing, was a density of no more than 24–30 families per hectare (10–12 per acre). On the European continent, however, central areas were built up with apartment buildings. Although the housing and planning programmes of these countries sought to reduce extreme densities, they contemplated the continued use of multi-family dwellings. The Swiss-French architect Le Corbusier was a leading exponent of the view that better living could be provided more economically by multi-storey structures equipped with centrally operated conveniences, surrounded by open areas available for common use, than by giving each family a private little plot and burdening it with the costs and inconveniences of maintaining a single dwelling. The issue was complicated by the problems of transport and traffic congestion and by those relating to the encroachment of the cities on the surrounding agricultural land. (Pl. 45b.)

The issue of metropolitanism versus smaller cities was even more difficult to resolve. Experience left little doubt that most of the problems of urban living which appeared nearly insoluble in the large metropolis assumed more manageable proportions in small cities. The costs of providing small cities with municipal facilities, transport, housing and space for decent living were generally only a fraction of those involved in providing equivalent facilities in metropolitan centres. On the other hand large numbers were necessary to make a wide variety of services economical. Opinions differed on the social effect of metropolitan living. One major school, following the pioneer British city planner Sir Patrick Geddes (1854–1932) and such architects as the American Frank Lloyd Wright (1869–1959), maintained that the huge metropolis was in and of itself an inhuman institution. They held that the evils of noise, congestion, traffic, tension and impersonality, even more than considerations of cost, should dictate policies designed to check metropolitan growth. Others however saw positive human values in the rich complexity of the metropolis.

In spite of the logic of the case for small cities and the persuasiveness of those who urged the dispersal of industry and population among cities of moderate size, the trend toward metropolitanism continued unabated throughout the period. Much industry continued to seek metropolitan areas rather than smaller centres, drawn by a combination of factors which outweighed the disadvantages of high land costs and the delays from traffic congestion; as noted by the Regional Plan of New York in 1922, the relevant question was not why any industry tried to locate near the centre of a metropolis but what prevented it from doing so. The attractions of the metropolitan communities as centres of cultural activities, as well as their role as expanding administrative centres, contributed further to the unchecked growth of the largest cities.

The very process of coping with the city's problems often stimulated still more growth. Once traffic congestion, overcrowding or inadequacy of facilities had developed, it was almost impossible for planning agencies not to recom-

mend measures to relieve the unsatisfactory conditions. Express highways or improved rapid transit to carry workers to and from work, new housing to lessen congestion, public utilities and social services to meet needs for water, sanitation, education and welfare all became imperatives which city administrations and planning agencies could not ignore. Yet in meeting these needs they made it possible for still more people to come into the city, occupy its houses and enjoy its facilities and services. Furthermore, the most powerful interests in the city were often those which stood to gain from continued expansion and they were reluctant to support steps to limit the process. At mid-century the metropolitan drift was still unchecked.

Two countries, Russia and Great Britain, made determined efforts to restrain metropolitan growth and to create new moderate-sized industrial towns.

Town planning in the USSR went along with general economic planning and was accomplished by the use of three principal means of control: ownership of urban land by the state, location of industry as determined by official plans, and the allocation of capital funds for construction as part of the overall capital budget of the country. In line with the development of industry and especially the opening up of the Asian areas and the eastward shift of population, town planning focused on the building of workers' settlements and new industrial cities. Some 200 new cities were built before the second world war and another 67 during the war.

Each town was planned as a distinct unit with due regard for its natural environment, its functions and its national culture and heritage, and with ample provision for parks, green belts and community facilities such as schools, nurseries, hospitals and cultural centres. Its central core was designed to give an impressive appearance and to provide a focus for the life of the community. Care was exercised to avoid too great contrasts between the central and suburban areas and to preserve standardization of design. These cities were planned with the objective of limiting their growth, generally to a population of less than 500,000.

At the time of the third five-year plan the policy was adopted of permitting no new industrial construction in large cities and of distributing medium- and small-sized enterprises to small communities. This policy was subsequently modified however on the ground that with modern facilities for transport it is more economical to concentrate the production of many types of finished products in a single centre. Instead of seeking to create cities of optimum size, urban planning looked toward large cities surrounded by suburbs, satellite towns and urbanized rural regions, so organized as to provide for appropriate specialization of function. The development of these large urbanized areas, together with the continuing development of small cities and new regions to supply raw materials and semi-finished goods, was envisaged as a rational pattern for an industrialized society and as a means of merging city and country and reducing the distinctions between urban and rural life.

Great Britain made a bold effort after the second world war to transcend the limitations of earlier planning measures. The comprehensive nation-wide programme adopted under the Town and Country Planning Act enacted during the war combined the principle of municipal responsibility with national supervision, financial aid and direct action. Initiative for local plans came from the municipalities, which used a planning procedure involving the active participation of citizen groups. The city of Birmingham for example prepared its development plan in 1952 on the basis of recommendations by twenty-one citizens' committees and eleven public bodies. The national government approved local plans or secured their modification in the light of the plans of other communities, it provided a measure of financial aid in carrying them out, it exercised the necessary controls over the surrounding country and it undertook directly the planning and establishment of new towns to relieve some of the pressure of population on the old. Plans called for the reduction of population density in the congested central areas and the systematic provision for facilities and services according to accepted standards.

In order to check the outward spread, prevent the blighting of rural areas and the loss of good arable land by the penetration of city fringes, and to ensure access to the country by the city dwellers, areas surrounding cities were designated as green belts in which land was restricted to agricultural use and urban construction prohibited. This was an important step, for little attention had generally been given in Britain or elsewhere to the relationship between city and surrounding countryside. Those responsible for city development had rarely been concerned with the effect of city expansion on nearby agriculture, while those interested in agriculture and rural life had limited their attention to the areas which continued to be farmed, while the no-man's-land between city and farm lay outside the scope of both.

A vital part of the overall British plan called for the creation of a series of new towns, outside metropolitan areas, designed and constructed by the national government to accommodate groups of relatively small industries and populations of approximately 50,000. These new towns were indispensable elements in the overall plan if the other objectives were to be achieved and the metropolitan cities prevented from spreading out in an ever-wider circle. The 1952 planning commission of the city of Birmingham, for example, calculated that there would be an overspill of 60,000 by 1971 if the plans were carried out for reducing the central density and for the orderly development of the city up to the edge of the green belt. The new towns were successful in attracting industry and population, but it was still not clear in the mid-1950s whether they would be developed fast enough to check the growth of metropolitan areas. (Pl. 20a.)

As Asian governments attempted to bring under control their booming metropolises, they found their situation even more difficult than that of the older industrialized areas. Asian cities were generally composed of a relatively small area where local *élites* and European residents patterned their living on

the cities of the West, while the bulk of the population lived in neighbourhoods which closely resembled rural villages in manner of living, social organization and often in types of dwelling. The extreme poverty of the population and the high rate of its increase presented insuperable problems to municipalities with their very limited resources and to the national treasuries subject to heavy demands for investment in economic development. With perhaps as much as 85 per cent of the population of Asian cities unable to afford decent housing constructed according to the most austere standards, most of the methods employed in the West appeared doomed to failure. To many it seemed that development of smaller cities was even more essential to the solution of urban problems in this region than in the West and it was the professed policy of most governments to encourage decentralization of industry and to attempt to check the flow from rural to urban areas by improving the conditions of rural life.

The representatives of the Asian countries attending the United Nations seminar on urbanization in Asia and the Far East at Bangkok, Thailand, in August 1956 concluded that a regional approach was essential to permit planning in terms of the interrelation between urban and rural areas and among communities within a region and to relate community planning to national development. They noted however that for their area the state of knowledge was so limited with respect to the many factors involved in industrial location, productivity, the development of a stable and efficient labour force, and the creation of the kind of environment conducive to economic and social growth that no positive guides were available. They expressed their confidence that 'it would be possible to find solutions which would mitigate the problems of urbanization, and to bring the fruits of modern technical and administrative progress to an ever-increasing number of people in Asia and the Far East',* but they stressed the urgency of the problems and the necessity for continued research and the co-ordination of activities in these fields. They noted, particularly, that urban development was not a problem in and of itself but was inextricably bound up with economic planning and productivity, education, health, housing and social organization. (Pl. 20b.)

4. *Community services*

The provision of services for the safety and protection of inhabitants, the education and welfare of citizens, the enjoyment of leisure and the cultivation of the arts were as essential to urban life as were water, housing or regulation of the use of land. These services became more elaborate, technical and costly as the size and complexity of the area to be served increased and standards of adequacy rose.

The organization, training and equipping of a police force became a specialized field, with its body of literature, professional associations, corps of

* *Conclusions of Joint UN-Unesco Seminar on Urbanization in the ECAFE Region, Bangkok, August* 8–18, 1956. (Unesco/SS/Conf. URB./W/21, ref. 2, 31 October, 1956.)

experts and inter-city and international technical consultation. Police often were trained in special academies in the use of scientific methods for the detection of crime, methods of directing and controlling traffic, and in the application of psychological principles to the handling of delinquency, group conflict and threats of disorder. Police departments of large cities were supplied with extensive equipment for communication, motor transportation, and laboratory analysis of evidence. Fire departments were equipped with elaborate mechanical equipment, municipal water systems provided high-pressure hydrants and a trained corps of men were maintained constantly on the alert. The cost of police and fire services, generally carried by the municipality, averaged 15 per cent of the budgets of US cities. When the motor car made it possible for persons committing a crime to escape beyond the jurisdiction of the municipal police, and road travel required policing, state, provincial or national governments set up police forces to supplement those of the localities.

Radically higher standards for every sort of welfare and cultural service, based on new knowledge and new understanding of need, involved increased expenditure and more technical operation. The bare school room equipped with little more than blackboard, benches and slates was replaced by the modern school plant, complete with workshops, laboratories, library and playing field; the isolation hospital for contagious diseases was replaced by specialized hospitals and clinics with the most up-to-date equipment for diagnosis, treatment and surgery. Libraries, museums, art galleries, recreation facilities were expected to meet the needs of young and old. Though high productivity in industrialized countries provided an economic basis for these extended services, their cost and complexity presented a constant problem of financing and an intricate task of planning and administration. In the countries of low productivity, standards and expectations of what cities should provide were far out of line with resources to support them.

5. *Municipal administration*

In the face of mounting problems and expanding responsibilities city administration became an increasingly difficult task which called for development of new administrative techniques. As the functions performed became more numerous and technical, city officials found themselves ill equipped for their responsibilities. City management became a specialized professional field and city managers trained in engineering, finance and administration were employed by increasing numbers of cities and smaller communities to bring to municipal operations many of the management methods that had been developed by business corporations.

Cities tended constantly to outgrow their administrative structure and financial resources. Tax rates and methods of financing geared to the support of more limited services failed to yield sufficient revenue. The situation was often complicated by the fact that municipal boundaries did not necessarily

correspond with the metropolitan area to which the city's population spread and municipal governments lacked jurisdiction over their suburban residents. These in turn came under rural or semi-rural authorities who had relatively little experience in providing the facilities and services required by urban dwellers and were often controlled by older residents who regarded the people from the expanding city as an intrusion into their way of life and a burden on their limited financial resources.

Various methods were employed in the effort to overcome the inadequacy of municipal organization. In some countries new jurisdictions were created such as water districts, school districts, port, bridge or highway authorities each with its own geographical area and jurisdiction over the particular problem for which it was formed. Where these special authorities were granted power to borrow money and exercise eminent domain, they threatened to overshadow the municipal government itself. National or provincial governments frequently came to the assistance of local units by making grants for the provision of specific services such as education or welfare. In some instances an attempt to bring order out of the administrative chaos was made by the creation of a metropolitan jurisdiction as in the London County Council which had been in existence since 1888, or the municipality of Metropolitan Toronto, Canada, which united the central city and twelve suburban municipalities in 1953.

6. *Citizen responsibility*

Efforts to make cities satisfying places for human living involved fundamental problems of social relationships and the citizens' sense of responsibility. In the industrial city the individual's life was fragmented into a number of separate pieces: his work, his residence, his religious observance, his associations for purposes of friendship, recreation or interest took him to different places and required him to form a part of a series of different groups. In contrast to his village counterpart whose role was defined by his status, the urban individual had to establish himself in each new set of relationships. He had to define his own role and secure acceptance and recognition, although class, sex, race, religion, length of residence, occupation or education might set limits within which he made his choices and adjustments. In much of his life the city dweller was anonymous: a worker, a tenant, a customer, a passenger. He moved about impersonally and alone, among thousands of people whom he did not know and, not knowing, often did not see. The cloak of anonymity gave him freedom in his choice of conduct but tended to release him from the sense of responsibility for his acts and his environment. The sociologists applied the term 'anomie' to this characteristic of the industrial city. The great mobility of many urban dwellers left them with few roots.

Suburban living in turn brought its own set of social problems. The people of suburbia lived in a semi-insulated locale where they were not related to their neighbours functionally since most depended on the distant city for their

livelihood, and where they often were exposed only to a small, relatively homogeneous fragment of the complex which made up the city. They were neither integral parts of a social, cultural and economic whole as were residents of villages or small towns, nor were they residents of the heterogeneous, anonymous central city where people rubbed elbows continuously with many different kinds and conditions or urban dwellers and where the evidences of the complexity of modern industrial life were constantly in view. Suburban residence moreover created a division in the focus of interest between the employed members of the family whose life was largely oriented to the central city and the non-employed members, chiefly the mothers and children, whose lives were lived in and oriented toward the place of residence.

The loss of the sense of belonging and of the responsibility which went with being a member of a small group appeared to many to be a factor at the root of chaotic conditions in industrial cities. Believing that people could not be expected to act responsibly except in relation to a relatively small unit, social workers and city planners in a number of cities and countries tried to develop some sort of neighbourhood structure through which the lost sense of belonging and responsibility would be restored.

Efforts at revitalization by way of the neighbourhood took a number of forms. The settlement house movement, inaugurated in London by the establishment of Toynbee Hall in 1884, brought groups of social workers to live in slum areas where they offered neighbourly friendship, facilities for recreation and adult education, and leadership in efforts to secure sanitation, public health services and better housing. The settlement movement spread to the United States and some cities of Europe, especially in France and the Netherlands, and grew markedly in the first decade of the twentieth century. Then it lost its vitality, as welfare services were extended, slum dwellers moved and the kind of neighbourliness envisaged by the pioneer settlement workers came to seem unreal.

The idea of neighbourhood organization around the public school as a centre for adult education, recreation, public discussion and democratic participation was popular during the same period, especially in the United States; in later years the principal application of the idea was in the community school programme of the Philippines. During the first and especially during the second world war the block or neighbourhood unit provided a basis for organizing civil defence in a number of countries. In the depression of the 1930s several American cities set up neighbourhood councils as a means of combating juvenile delinquency. British public housing projects were commonly equipped with community buildings designed to serve as neighbourhood centres, as were some projects in the United States, the Scandinavian countries and a few places in Latin America.

Yet few enduring successes could be recorded for the attempts to use the urban neighbourhood to bring new vitality into the older industrial cities and responsible participation to its citizens. After more than fifty years of experi-

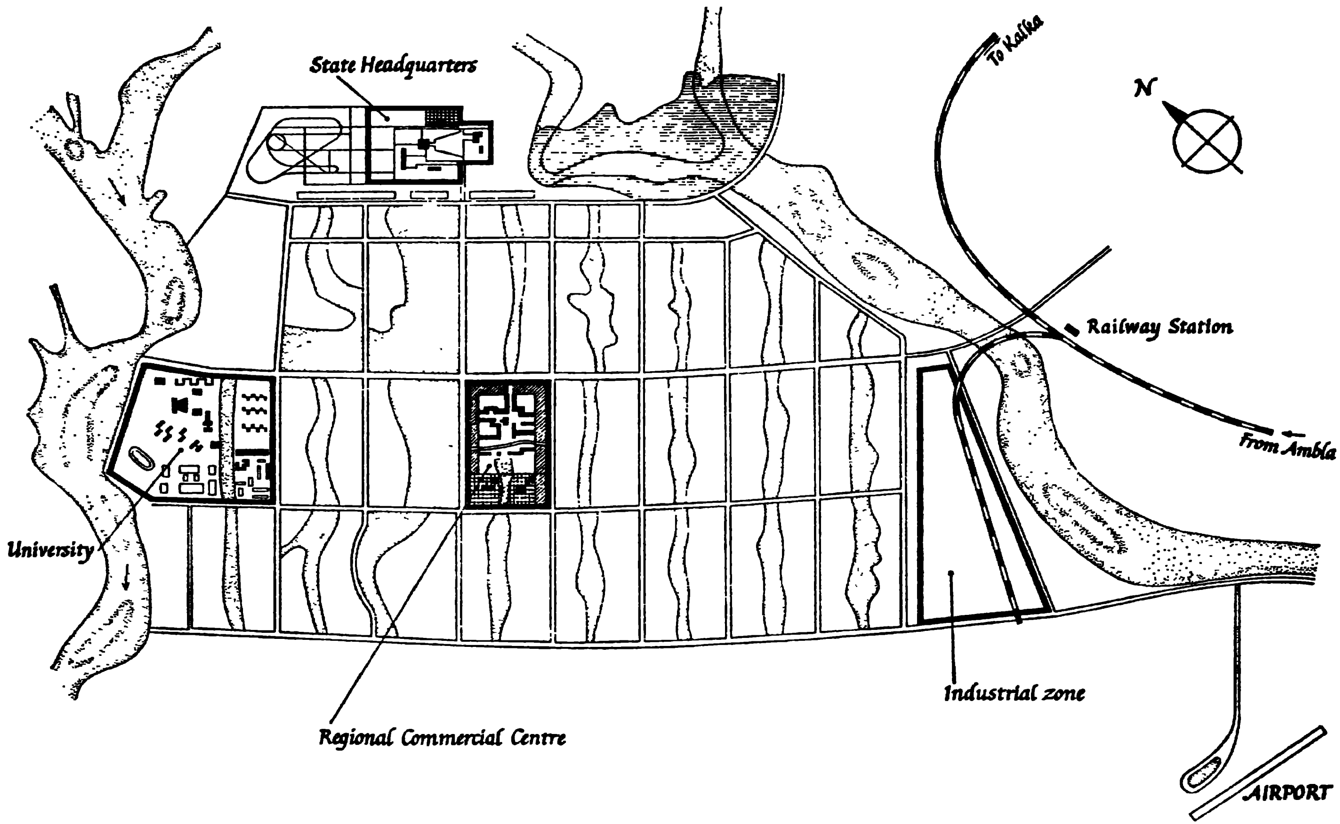

FIG. 3. Chandigarh, Punjab (Le Corbusier, 1951): the layout of the city.

The area of 16 square miles, for a population of from 150,000 to 500,000, comprises four functional zones; the administrative services of the State of Punjab, an academic, a commercial, and an industrial centre. The several residential sectors are of 800 by 1200 metres each. [*Courtesy of Dr N. S. Lamba, Chandigarh.*

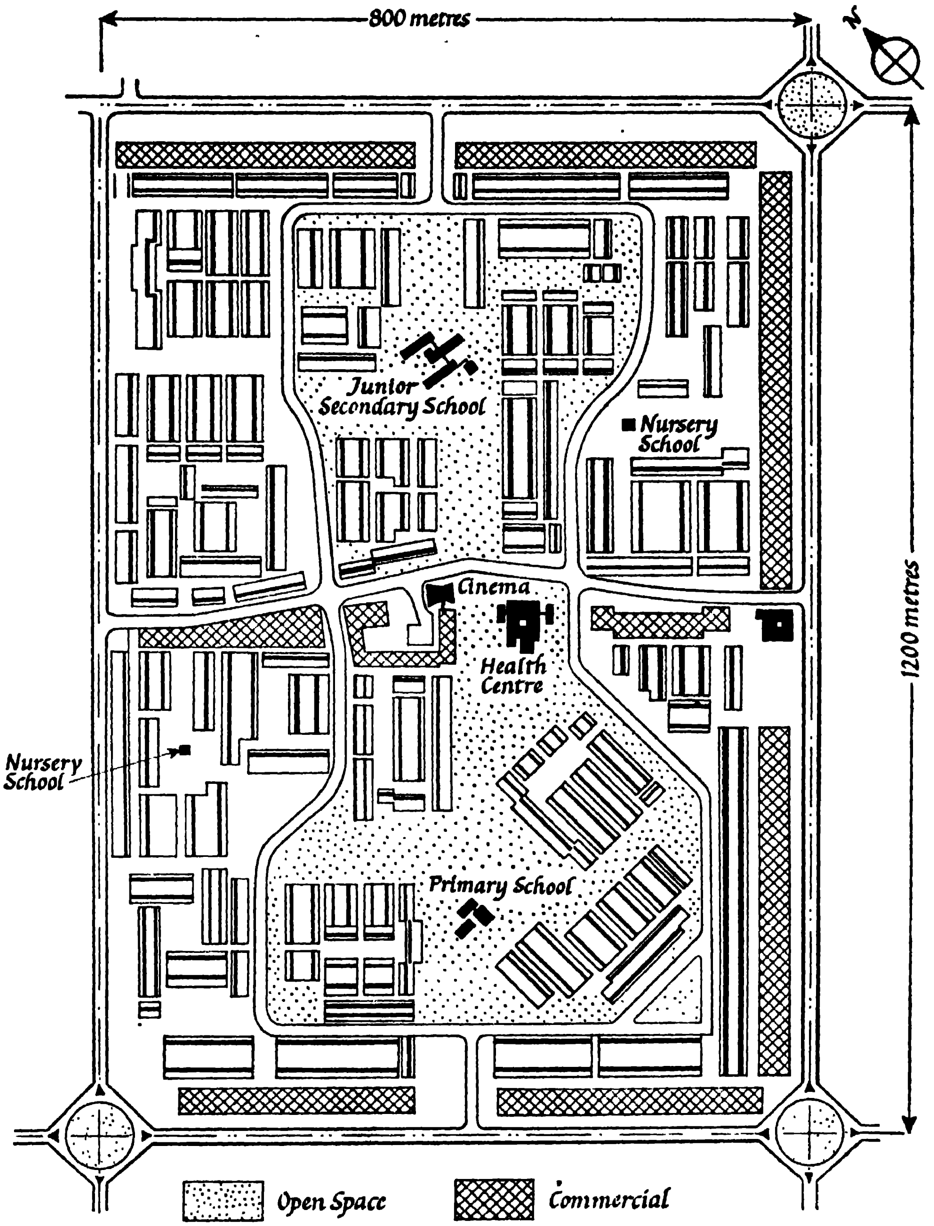

FIG. 4. Chandigarh, Punjab (Le Corbusier, 1951): the layout of a residential sector.

Accommodating from 5,000 to 15,000 persons, each sector is a self-contained unit providing shops, recreational facilities, health centres, community centres, nursery and junior schools. Outer roads are left free for motor traffic while the sectors are connected by a system of pedestrian and cycle tracks. The linear shopping areas along the south side of High Street and the compact groups of from 150 to 200 houses were designed to suit local climatic conditions. [*Courtesy of Dr N. S. Lamba, Chandigarh.*

ment, the total impact on the character of urban life had been negligible. Some people in fact doubted the validity of the neighbourhood concept in relation to urban living, raising the question whether the ability of the city dweller to join with those who shared common interests might not be a sounder basis than the local neighbourhood for social relations in the metropolitan community.

In the Asian cities, where neighbourhoods often resembled villages, it remained to be seen how these units would function as their members became more fully a part of the industrial complex which was developing. A few Asian and Latin American cities in their attempts to cope with their boundless problems experimented with ways to combine the limited resources of the municipal or national government with the efforts of people on their own behalf. Impressed by the success of co-operation and self-help in the community development programmes at work in villages, they began to apply similar methods in urban communities as well.

The problem of how to bring responsibility, participation and wholeness to the lives of city residents was a persistent challenge to all concerned with the quality of life in the urban environment.[2]

II. THE RURAL ENVIRONMENT

While an increasing proportion of the people everywhere were adapting themselves to conditions of city life, the great majority of the world's people continued to live in rural areas. Yet the same influences were tending to urbanize the countryside and to reduce the differences between urban and rural life. Wherever roads broke down isolation, radios brought programmes originating in urban centres, electricity made possible some of the conveniences of urban living, schools and health services reached rural areas and larger proportions of farmers were drawn into the market economy, the self-contained isolation of the peasant village or rural hamlet tended to disappear.

The pattern of change varied greatly from area to area. In Japan general electrification, roads and universal education in rural areas, together with intensive cultivation of plots on the outskirts of towns and cities, blurred the line between urban and rural life. The USSR pursued a deliberate policy of minimizing the differences between rural and urban living by introducing into the collective and state farms as much as possible of the technology, education, health services and cultural activities that characterized urban life. Throughout western Europe and in much of North America the widening influence of metropolitan areas touched more and more rural communities, making them into appendages of urban centres. North American farmers, on electrified farms and with access to town by highway, shared the tastes and much of the manner of living of their urban counterparts.

Under these influences, many of the institutions of rural society lost their vitality. With entertainment available at the cinema in the nearest town or over the air, the social gatherings of village groups—around the church, lodge,

family, co-operative or other unit—lost some of their exclusive role as providers of recreation. When the voice of a national leader was heard directly by radio, that of the village elder lost some of its exclusive authority. Exposed to other manners by way of the cinema, visits to town or the sight of town people in the village or on the roads, traditional village customs lost some of their sanction. Distinctive modes of dress tended to disappear.

The spread of literacy opened the door to new knowledge and ideas which not only changed agricultural practices but altered patterns of rural living and attitudes associated with them. Where rural life was radically reorganized through the introduction of collective farming, or in the case of China the establishment of communes, a new set of rural institutions was established with a new locus of authority and prestige. Elsewhere the tendency was to undermine the old rural institutions without substituting new ones specifically related to rural life.

The rural communities least affected by the changes of these years were the peasant villages of Asia and the Near East. Here too, however, the ancient patterns of village life were disturbed as bit by bit the same influences which were modifying rural life in the more industrialized countries penetrated to these areas. Even the rural communities in tribal areas of the western hemisphere, Africa, Asia and the Pacific were touched, as their men were drawn off for work on commercial plantations or in mines or industry.

The process of change was consciously speeded up and efforts made to guide it in many areas. Most countries with advanced agriculture established advisory and educational extension services which went beyond advice on the improvement of agricultural practices to advise on farm living and the sponsorship of youth groups and groups of men and women interested in improving aspects of rural life. After the second world war the central governments of most of the new states sought to stimulate villages to modify their way of life in accordance with standards and concepts of sanitation and health, nutrition, education, construction, the application of technology and participation in political activity formulated by those with an urban outlook on life, and they took steps to create new urbanized units in rural areas with which village life could be integrated.

NOTES TO CHAPTER XVIII

A special resolution on housing construction adopted in the USSR in 1957, provided for 'the liquidation of the country's housing shortage' within 10 to 12 years. This decision is being successfully put into effect. Between 1957 and 1962 in the Soviet Union there were built 12 million urban apartments and more than 3·8 million rural homes. During the past ten years 108 million persons (approximately half of the population) have moved into new homes and improved their living conditions.

('*O razvitii zhilishchnogo stroitelstva v SSSR. Postanovleniye Tsk KPSS i Soveta Ministrov SSSR*' ('On the development of housing construction in the USSR. Resolution

of the CC of the CPSU and the Council of Ministers of the USSR'), *Pravda*, August 2, 1957; *Bolshaya Sovetskaya Entsiklopediya. Ezhegodnik, 1963*, p. 80; *Pravda*, June 20, 1964.)

2. Professor M. J. Wise regrets that 'the authors are constrained to generalize about cities and the similarities of their problems'. Being 'especially interested in the differences between cities', he notes that 'as between countries there exist great contrasts in city problems and in city size, form and function. Even within a small country, such as ours [Great Britain], it is difficult to generalize for there are major contrasts between the problems of, say, London and those of, say, Glasgow or Blackburn'. Professor E. N. Anderson observes that, without attempting to expand upon all the implications of Professor Wise's criticism, one may emphasize an aspect which would seem to be essential for understanding the city. This is its aesthetic dimension, the extent to which and the ways in which the city creates a personality for itself by the aesthetic use of its geographic setting and by the beauty of its centres, public buildings, parks, homes, and other features which impress character upon the entire urban life. Studies have been made which show that in the eyes of residents a city may be as amorphous and centreless as a pancake, as ugly and drab as a mill town or urban slum; in short, unattractive in spite of the presence of wealth. Character and reputation of a city may depend upon relatively few city landmarks, for example upon a cluster of public buildings and a square or park, which can be recalled as symbolizing the city. When visitors ask what to see, citizens can refer to these monuments with pride as embodying the best achievements of the city. Elsewhere distinguishing features may pervade the whole community, for example in aesthetically designed and well-kept homes, parks and tree-lined streets, in cleanliness, colour, pleasant neighbourhood facilities, and other evidences of the citizen's concern for and enjoyment of his surroundings. Other cities may have other means of individualizing themselves; in all cases some qualities of beauty or distinction must be present, in forms which can be identified by the citizens with themselves and in which they can share pride of achievement.

The conception can be extended beyond the city to the region: phenomena of nature, Victoria Falls, the Nile river, Fuji mountain and the like, were and continue to be objects of pride. In recent decades they must share appeal with man-made pieces of gigantic architecture or sculpture—Boulder and Aswan dams, radio towers, airports, and the numerous other manufactured manifestations of aesthetic as well as scientific and engineering genius that constitute the great works of art of our age. They are the twentieth century's Pyramids, Gothic cathedrals, Greek and Buddhist temples, the work of co-operative activity, of individuals representing many diverse skills and many forms of aesthetic expression, and made possible by the material participation of millions of tax-payers and stockowners. They have public character, they reveal grandeur, they transcend the individual and the momentary, to impress those who see them by their union of beauty and public service. It is in this way that beauty achieves a democratic character and both city and region assume aesthetic validity.

For further reading the following may be consulted:

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Julian H. Levi, *Municipal and Institutional Relations within Boston* (Chicago, 1963).

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CHAPTER XIX

TREATMENT AND PREVENTION OF SOCIAL BREAKDOWN AND PROVISION OF SOCIAL SERVICES

I. GROWTH OF SOCIAL SERVICES

SOCIAL programmes, undertaken initially in order to treat or prevent social breakdown, expanded tremendously, first in the industrially developed countries and then in those in process of industrialization. The programmes were made necessary by industrialization and urbanization and were specifically directed toward meeting conditions arising out of these twin processes. As the growth of industry and the migration to cities broke down social patterns of pre-industrial societies, the need for substitutes for older sources of welfare and security became apparent. At the same time industrialization provided the resources to support services which a less productive economy, more fully devoted to subsistence, could not afford. In the process it set standards toward which even the newly developing countries, for all their lack of resources, were forced to strive.

The development of social services moreover reflected the conviction that the community must assume positive responsibility for the social and economic welfare of the people. The United Nations Universal Declaration of Human Rights included a series of social 'rights' which clearly identify thir document as a product of the mid-twentieth century, in contrast to earlies documents which had proclaimed political and civil rights. Although the enumerated social rights were far from being made a reality during these years, their expression symbolized their world-wide acceptance as objectives to which societies were committed.

The major social services to meet the needs of all the people for health, education, housing and recreation are discussed in other chapters.* The present chapter is limited to the services and programmes designed to intervene where social breakdown threatens or has occurred, either to protect or to treat the individual or to protect society. As the need for such services became ever more apparent the social sciences were called on to provide a more scientific basis for them than the pragmatic approach in terms of which they had operated in the past.

Every society has had some system of care for its dependent, displaced and delinquent members—for the stranger, the orphan, the sick and disabled, the

* See Chapters XV, Health and Population; XXVI, Education; XVIII, The Environment; XXVII, Use of Leisure.

aged, the penniless, the felon—through the extended family system, institutions maintained by religious bodies, mutual aid within occupational fraternities, obligations of feudal landlords or other superiors, or the responsibility of the local community. The problem of the twentieth century was to develop systems appropriate to the conditions of industrial society.

In the industrial countries of Great Britain, the United States, the British Commonwealth and parts of northern Europe, the basic pattern of public responsibility for those in distress had been inherited or adapted from the Elizabethan Poor Laws of the early seventeenth century: local responsibility, maintenance of public institutions for the mentally ill, the indigent sick, orphans and the aged, and work relief for the destitute able-bodied. The 'means test' restricted public aid or support to those without other resources. With the development of industry the means test had been coupled with the principle that the level of assistance must be kept well below that of wages in order to make sure that those able to work would not choose idle dependency over industrious labour. This system of social assistance rested on the assumption that the individual had a moral obligation to work, that poverty and dependency were a reflection of personal inadequacy and that the successful and well-to-do were morally superior to their poorer fellows and had a responsibility to correct their weakness as well as to succour them in need. These assumptions were sanctioned by Protestant religious convictions which, as the German sociologist Max Weber pointed out in *The Protestant Ethic and the Spirit of Capitalism* (1904–5), gave capitalist economic development much of its drive.

In areas dominated by Catholic attitudes charity continued to be regarded as an act of piety enjoined by religious duty on the giver, and most social assistance took the form of benefactions by individuals and institutions sponsored and manned by religious orders.

By the opening of the twentieth century the conviction had grown that much of the poverty and misery from which the needy suffered arose from factors beyond their control, and that blame and responsibility rested on society rather than the individual. It had become apparent that industrial societies with their systems of individual wage-earning limited to the period of actual employment did not offer the cushions against the normal hazards of life provided in an agrarian society by the pooled resources of an extended family.

Measures had been enacted in industrial countries to reform the basic conditions of the labouring classes—such as long hours, bad housing, inadequate sanitation, child labour and the labour of women in hazardous tasks. Public concern had been aroused over the plight of dependent groups, especially children herded in almshouses, and over the inhuman treatment accorded to the insane; and programmes had been initiated for providing children with special institutions or placing them in foster homes and for treating the insane as mentally ill persons rather than as evilly possessed subhumans.

The idea of rehabilitation had begun to replace that of relief or punishment in the work of some of the friendly visitors who hoped that the families in need whom they helped might become self-supporting and self-respecting, and in the movement for prison reform. The German programmes in the 1880s for insuring industrial workers against sickness and accident had established the principle that risks should be spread through society, not carried by the individual worker, had introduced the method of social insurance and had laid the basis for the social security systems that spread over the world in the twentieth century.

Although the comprehensive scope which the social services were to assume was hardly foreshadowed at the beginning of the twentieth century, the way had been opened for development of the concept of the welfare state and for the changes in principles, techniques and focus of responsibility which it involved.

Half a century later, when the United Nations undertook a world-wide review of programmes of social development* it found all types of programmes in the process of rapid extension in countries and territories at all levels of economic development and with all manner of political structures. Such programmes were similar in scope and objectives, regardless of the type of government or degree of economic development, although their forms differed as a result of their historic background and the structure of the society of which they were a part. The field of social welfare was one in which technical assistance was earnestly sought and in which international and national agencies worked to make available the best knowledge and the best social techniques and to stimulate their extension.

In countries with a long tradition of private philanthropy and a heritage of institutions established before the social attitudes of the mid-twentieth century had developed, the programmes which emerged combined both public and private responsibilities. The twentieth-century trend, however, was towards an extension of the area of public concern, as was evidenced in Britain and the Scandinavian countries which had some of the oldest and richest traditions of private welfare effort and yet developed some of the fullest public programmes. In the communist states which achieved rapid industrialization, social programmes were included as part of the total structure of economic and social administration by the state.

In the newly industrializing countries of Latin America and Asia, whose private welfare services were generally limited in scope and highly personal, strong pressures developed for public measures to meet overwhelming problems of mass need. These countries faced a dilmema that had not beset the older industrial countries, which had undertaken broad social welfare programmes only after they had already developed the economic potential to support them. In the social climate of mid-twentieth century they could not delay their welfare efforts or adopt as goals for their people more limited con-

* *International Survey of Programmes of Social Development*, 1955.

cepts of human dignity and well-being than those which other nations had accepted, yet their economic means were limited and their resources strained. Although they generally devoted a smaller proportion of their national budgets to social programmes than did the industrialized countries, they were doing far more than the latter had done at a corresponding stage of industrialization. Some, such as Chile whose welfare services developed hand in hand with the growth of industry, built up comprehensive programmes and became pioneers and leaders in the welfare field.

Though all programmes had much in common, countries differed markedly in the extent to which they applied new knowledge, in the emphasis of their programmes, their choice of methods and the comprehensiveness and generosity of their approach to social needs. The Scandinavian countries were among the most consistent and self-conscious in developing an overall approach to welfare on every front and in constantly revising all types of programmes and institutions in line with the growing potentialities of their economies and with expanding concepts of needs and services.

New Zealand was outstanding in its general programme of social assistance through which it incorporated into a single comprehensive system of aid to all, in all types of contingencies, what many other countries administered as a multitude of fragmentary benefits. Britain after the second world war put together a number of different programmes which had grown through the years, to form a 'cradle to grave' system of economic protection against risks and to provide health and some welfare services. The United States pioneered in individualizing many services and expanding their scope, but programmes were applied unevenly and reflected great differences in local resources and ideas.

The USSR and other communist countries included the provision of social security against risk as a basic condition of life and labour and they provided a range of pensions, benefits and services which supplemented and reinforced what workers received through wages. Israel drew on the best available knowledge and experience in designing and operating the social services which from the start were an integral part of this welfare state.

The newly developing countries, faced with mass problems of economic and social inadequacy, instituted programmes of community development which stimulated whole villages to undertake self-help activities designed to raise their levels of living. At the same time they made such efforts as their resources permitted to provide for special groups such as destitute children, the blind or crippled, and to apply to these efforts new techniques which were consistent with the conditions of their society.

All programmes of social welfare, whether in industrially advanced or newly industrializing countries, showed common trends. All brought a growing understanding of human needs and potentialities to the protection, care and rehabilitation of the major groups needing aid—dependent children, juvenile delinquents and adult offenders, the handicapped, the mentally ill,

the aged. All combined, in some form, both scientific knowledge and the philosophies and value systems of their society and all were carried out by persons equipped with some combination of professional training and dedication to the service of their fellow-men.

The trends which are noted below characterized the development of welfare services and policies around the world. Actual provisions for care, treatment and prevention, however, remained far below prevailing standards and accepted policies. Almost universally, limited funds and a shortage of adequately trained personnel hampered the development of services; attitudes of indifference or rejection of those in need and ignorance of sound approaches to social problems often persisted in spite of public policy and growing knowledge. Model programmes were sometimes confined to the principal centres or special institutions.

Yet however great the gap between principles and practice, the emergence of universally accepted criteria and a common, positive approach to the welfare of those in need and common trends in methods adopted was one of the most distinctive features of the twentieth century.

II. PROTECTION, CARE AND REHABILITATION OF DEPENDENT GROUPS

1. *Dependent and neglected children*

Children deprived of adequate parental care have always presented a problem of community responsibility wherever they could not be absorbed into an extended family group. In the twentieth century measures for the protection, care and welfare of dependent, neglected, handicapped and delinquent children became central features of the welfare programme of every country.

The need for such measures was intensified by many factors in urban industrial life. The extended family was no longer generally at hand to assume responsibility when something happened to the immediate family. Although the number of orphans was reduced by lowered death rates of parents, especially by the decrease in maternal mortality, family breakdown and desertion by the breadwinner continued to leave many children without support or care. The number of children born out of wedlock remained a large and growing problem in many areas. Wars and population displacements left large numbers of children homeless.

Traditional methods of providing for dependent children by binding them out as servants or apprentices or by herding them into local almshouses along with other public charges were generally discredited by the opening of the twentieth century. In most countries, specialized asylums for orphans had been established by religious bodies, fraternal organizations, individual charity and public agencies. Organizations had been formed to protect children against abuse and to promote standards for their care, and children's institutions had been brought under licensing or other supervision by the

state. Some children were supported by the state in foster homes, selected and supervised by a public agency.

The extensive child welfare programmes developed in the following years, although differing in comprehensiveness and in detail, showed common trends which reflected an increasingly sympathetic attitude toward children, a growing body of knowledge of their needs and much international consultation and co-operation on their behalf.

These programmes recognized the central importance to the child of its own home and tried to maintain the home or to provide the nearest approximation to it, especially for very young children. All evidence showed the extreme importance of providing a mother figure during the infant's earliest development; studies of babies cared for in institutions revealed serious retardation in mental as well as in emotional development even where physical conditions were entirely satisfactory.*

The principle that no child should be taken from his home for economic reasons alone was clearly established in the early years of the century and was incorporated in the declaration of the White House Conference on the Care of Dependent Children in 1909 and by the Pan American Child Congress in 1919. It led to the inauguration of mothers' or widows' pension schemes to enable mothers to remain in the home in order to look after their children, and the inclusion of survivors' benefits in systems of social insurance.

Mothers' pensions were provided between 1911 and 1913 by New Zealand and eighteen of the states of the United States and by Canada and the Scandinavian countries during the first world war. The German social insurance scheme added survivors' benefits in 1911 and these were included in the social insurance of Great Britain and other continental European countries after the first world war.

In the second quarter of the twentieth century most industrialized countries extended insurance or assistance benefits to cover virtually all children deprived of paternal support; some included housekeeping aids to mothers in case of illness in order that young children could remain constantly in the home. Provisions for the daytime care of children of working mothers were also widespread. They were general in the Soviet Union, both crèches for young children and after-school centres for older ones. In some Latin American countries large employers were required by law to provide day-care facilities. Elsewhere such facilities were maintained by welfare agencies, industries or local public bodies if the need was apparent.

The use of substitute homes for children without homes of their own was accepted by most well-developed child welfare programmes as the most desirable practice, in preference to institutional care. Welfare agencies endeavoured to recruit and supervise foster homes where children were boarded at public expense. Initially these agencies were primarily concerned with the ability of the foster home to provide for the child's physical health and care,

* See John Bowlby, *Maternal Care and Mental Health*, *op. cit.*

but as it became apparent that the emotional quality of the home was even more important to the child than its physical aspects, they gave primary attention to attitudes and relationships in the homes in which children were placed.

It was not easy, however, to ensure responsibility on the part of foster parents and to make certain that they were not taking in children in order to use them as servants. The latter practice was sufficiently serious in some countries to make the United Nations include it in its study of forms of slavery which still persisted in 1951. In some countries the inauguration of foster home placement was delayed and institutions maintained, contrary to the general trend, because no satisfactory machinery for supervision had been developed. In some, the local culture made it very difficult for families to give the foster child the feeling of belonging which was the rationale of the foster home system. Especially for older children, institutions continued to be an important means of providing for those who lacked parental care.

Institutions, in turn, were redesigned in order to approximate conditions of home life. Barrack-like dormitories were discarded wherever possible in favour of a group of cottages, and the rigid classification into age and sex groups tended to be replaced in some of the most modern institutions by the more normal grouping of children of different ages and sexes. Institutions ceased to be regarded merely as means of providing custodial care and were recognized as possible treatment agencies; specialized institutions were designed to meet the needs of children with special problems and to provide kinds of care which could not be provided or were not needed on a large scale. The Soviet Union, whose initial major problem of child welfare was to provide for the large number of homeless children left in the wake of the civil war, developed special children's colonies and homes where children received schooling and labour training as well as care.

Twentieth-century child welfare programmes rested on a concept that the child has rights which society should protect and that he should not be the one to bear the burden of circumstances such as illegitimacy or poverty which are beyond his control. Legislation with respect to children born out of wedlock and provisions for legitimization, establishing paternity and adoption reflected the general trend toward the protection of the interests of the child.

Family law was revised in most countries so as to reduce the distinction between the rights and status of children born out of wedlock and those born to married couples, although some countries such as Spain and Portugal retained laws which gave legal protection to legitimate children only, while a few such as Cuba eliminated legal difference altogether. Legislation tended to strengthen legal means to establish paternity and to exact the responsibilities of parenthood. It sought to remove social stigma from the child by such procedures as eliminating identification of illegitimacy from birth certificates, and to ensure that children born out of wedlock would not be excluded from such social benefits as family allowances, social assistance to dependent children, survivors' insurance or the allotments to dependents of military personnel.

Adoption as developed during the twentieth century was designed primarily as a means of providing a child with a home and parents, and of protecting the child, its natural parents and its adoptive parents against unregulated traffic in infants by unscrupulous persons. Where, as under the Roman law, adoption had been designed primarily as a means by which an individual could secure an heir, or where it was hedged about by restrictions aimed at protecting the interests of members of the family in family property, laws were modified in the interest of the adopted child. While some countries continued to make no provision for legal adoption and others excluded the adopted child from inheritance, the United States, most European countries, Great Britain after 1926, and several of the countries of Latin America established the machinery for incorporating adopted children into a family on a basis identical with that of children born to the family. The legal procedure, entrusted in most instances to the juvenile or family court, generally required a joint petition by both adopting parents, unconditional release by natural parents, careful investigation of the adoptive home by an authorized welfare agency, physical and mental examination of the child and often a probationary period before the adoption decree could become final.

The concept of children's rights which society was under obligation to safeguard and promote grew broader and encompassed emotional needs for security, affection and identification. The most complete formal statement was contained in the Children's Charter adopted by the White House Conference on Child Health and Protection in 1930, generally regarded as the children's 'bill of rights'. It proclaimed 'for every child' the right to spiritual and moral training, understanding and the guarding of his personality as his most precious right; a home, and the love and security which a home provides; for the child who must receive foster care, the nearest substitute for his own home; health protection at birth through pre-natal, natal and post-natal care of his mother, and from his birth to adolescence; a safe and wholesome home and school; a community which recognizes and plans for his needs, protecting him against physical and moral dangers, educating him to guard against accidents, and providing for his recreational, cultural and social needs; education which develops his individual abilities and prepares him for life, for a vocation, for parenthood and for citizenship; for the physically or mentally handicapped child, such care and training as will enable him to become an asset to society rather than a liability; for the child in conflict with society, the right to be dealt with intelligently as society's charge, not society's outcast; the right to grow up in a family with adequate and stable income and to be protected against labour that stunts growth, limits education and denies the right of comradeship, of play and of joy; for every rural child, as satisfactory school, health and other services as for the city child.

There was perhaps no other field of social welfare in which international co-operation was more readily forthcoming and in which there was a freer exchange of experience and agreement on principles. In the 1950s the United

Nations children's agency, UNICEF, was co-operating with the governments of some ninety-five countries and territories in direct assistance to meet emergency needs and in the development of child welfare programmes in the effort to extend the rights of the Children's Charter to 'all the world's children'.

Yet gaps were everywhere apparent betweeen accepted standards or aims and actual practice. Few places enjoyed a range of facilities which would permit those in charge of dependent children to place them in relation to their particular needs. Suitable homes for foster care or adoption were often lacking. Institutions administered by underpaid and under-trained staff on inadequate public payrolls, by religious orders with rigid practices or by other agencies without adequate staff, equipment or understanding were still far more numerous than those which reflected the best understanding of children and the principles to which most communities were committed.

2. *The juvenile delinquent*

The Children's Charter asserted the right of the child who was in conflict with society to be 'dealt with intelligently as society's charge, not society's outcast'. In the twentieth century the number of children regarded as delinquent increased markedly in many places and juvenile delinquency came to be considered one of the most serious and central problems of the times.

In line with changing attitudes the juvenile delinquent ceased to be an offender needing punishment and became a child needing help. New understanding of behaviour brought new procedures and institutions for his treatment. Research into the causes of delinquency, however, revealed complex and deep-seated social and psychological factors which often baffled efforts at treatment and prevention.

Under all legal systems, the very young child—under seven in the Roman law and codes derived therefrom—was assumed to be incapable of committing a 'crime' because of his inability to distinguish between right and wrong. Older children were either presumed to be less accountable for their acts than adults, or subject to less severe punishment for the same offence, but up to the close of the nineteenth century they were regarded in some degree as guilty of criminal behaviour if they violated a law applicable to adults.

The juvenile court, first introduced experimentally in Illinois in the United States in 1899, offered a new approach and a new concept. This type of court was not a judicial body which established the child's guilt and meted out punishment; it was a protective agency to determine the reason for his behaviour and to help him to conform to socially required norms. The court's action was based on a thorough social and psychological investigation of the child and its procedure was informal and private.

As the juvenile court system spread throughout the countries of Europe and to other parts of the world, it gradually introduced the principles and procedures of social investigation and treatment in place of judgment and punish-

ment. Yet by mid-century the transformation was far from complete. Vestiges of criminal procedure remained in the practice of many juvenile courts in the United States which continued to charge the child with a specific offence and establish the facts of his 'guilt', although the Standard Juvenile Court Act issued as a model by the United States Children's Bureau in 1949 set forth the principle that no guilt should be involved but rather that 'it should be established whether a child, because of his ascertained acts, condition or environment is in need of the care and protection of the State'. An element of 'guilt' remained in the British and most continental European practices, although it was largely eliminated in Belgium. Under the stimulus of the Inter-American Institute for the Protection of Childhood the trend in the Latin American countries was to discard the term 'delinquency' altogether, and one country after another transferred its juvenile courts and related agencies from the jurisdiction of its justice department to its department of welfare or to a children's agency.

Application of the concept of treatment rather than punishment depended not only on the court but on related agencies—the police, the detention institutions and the agencies which investigated the child, diagnosed his problems and supervised his activities.

The attitude and practice of the police was of prime importance, since the child's behaviour was most likely to come first to their attention. Since most police training and procedures were not designed to produce an understanding attitude toward children in trouble, police departments in some cities, including parts of the United States, the United Kingdom, the British Commonwealth, the Netherlands and some Latin American countries, instituted separate specially trained juvenile squads. The duties of these officers assigned to work with children sometimes included supervision of playgrounds and the organization of recreation activities such as boys' clubs, in an effort to promote a positive relationship between young people and those in authority.

Institutions for the detention of juvenile delinquents were greatly modified in form and procedure. Reformatories had been initially established in the nineteenth century in order to separate young offenders from adult criminals housed in jails and prisons. They resembled prisons, however, in their bars and barrack-like structures, and their procedures were largely impersonal and based on the assumption that lack of discipline and respect for authority were characteristics of the delinquent which the institution should endeavour to overcome.

In line with changing concepts these institutions were reoriented from places of detention to treatment centres and were given other names such as 'training schools'. As new understanding of the delinquent child made it apparent that he usually needed the opportunity to be responsible for his actions, to belong to a group, to establish personal relations and to develop his capacities, the locked, regimented, uniformed barracks life was recognized as unlikely to provide an effective form of treatment. The model juvenile

institutions in all countries came to be designed without bars or walls and to consist of cottages where each child could be a member of a small group.

Supervision of the delinquent child was provided by some form of probation system. In Britain the probation system which had been occasionally used under the common law was made general in 1907; on the Continent the French and Belgian form of conditional suspension of punishment was generally adopted. These and similar systems became integral parts of juvenile court procedure, and the most frequently used form of treatment in most courts was to place the child under the supervision of a probation officer. Even where the child was placed in an institution a probation officer often had responsibility for following his progress there and supervising his return to home and community when he was released.

The soundness of the juvenile court's action and the effectiveness of treatment depended upon the adequacy with which the child's case was investigated and his problems diagnosed. Such investigation and diagnosis was variously performed by the juvenile police, a welfare agency or by the juvenile court itself, which often came to include a corps of social workers and a psychiatric clinic.

A mounting body of research revealed the necessity for distinguishing between children whose mental and emotional development was normal but whose social circumstances resulted in anti-social behaviour and those whose behaviour was rooted in mental deficiency or emotional disorder. Studies of social factors presumed to be linked with delinquency readily established positive correlations between delinquent behaviour and such conditions as poverty, broken homes, neighbourhood disintegration and the coexistence of cultural sub-groups in marginal areas, and they showed the problem to be intensified where rural migrants or immigrants found their traditional values and authority no longer supported in a strange and confusing urban milieu. Yet not all who suffered from these social disadvantages became delinquent and a disturbingly large and growing number of delinquents came from ostensibly favourable conditions. Research was therefore focused increasingly on the individual child in the effort to determine the complex of factors which entered into the formation of his personality and motivated his behaviour. By mid-century there was world-wide recognition of juvenile delinquency as a problem in mental health; the first monograph issued by the World Health Organization dealt with *Psychiatric Aspects of Juvenile Delinquency* (by Lucien Bovet, Geneva, 1951).

All studies pointed to the conclusion that delinquent behaviour was a symptom of the child's efforts to resolve his own problems, and that in seeking to treat the disease and not merely the symptom it was essential to identify what it was that the behaviour expressed. For the large majority of delinquent children whose unacceptable behaviour grew out of a social situation, treatment involved the provision of a social environment in which the child could

fulfil his needs within the framework and values of adult society. For the few who suffered from severe personality disorders, only the most highly skilled psychiatric treatment could hope to repair the personality damage which had been suffered. The best equipped and most progressive of the courts and the diagnostic and treatment agencies in each country were guided by these considerations in their approach to the ever-mounting volume of juvenile delinquency which continued to be a disturbing feature of the social changes of these years.

But the best equipped and most progressive courts and institutions remained the exception rather than the rule. Lack of sufficient trained personnel for investigation and supervision hampered the work of a large proportion of the juvenile courts. Probation officers were generally insufficient in number and inadequately trained. Many older types of institutions for juvenile offenders continued to operate and to perpetuate outworn procedures long after these had been discarded in principle. Means of early detection of delinquent tendencies and effective prevention were even more limited than adequate courts and institutions.

Surveying the world situation for the World Health Organization in 1951, Dr Lucien Bovet found only hesitant beginnings in the selection and training of staffs for work with juvenile delinquents along modern lines. Such outstanding experiments as the training centre at Amersfoort, Netherlands, were very few, some types of training were only to be found in the United Kingdom and the United States, and the vast majority of staffs of juvenile institutions in Europe and the United States lacked the necessary technical knowledge and emotional stability to make these institutions effective instruments for the treatment of the delinquent child.

3. *The adult offender*

The treatment of adult offenders followed somewhat the same course as that for juvenile delinquents, although the concept of criminality and procedures for establishing guilt remained. Developments in this field were chiefly in the reform of prisons and the modification of sentences.

In the latter part of the nineteenth century a movement for prison reform attacked the concept of prisons as purely custodial institutions, to protect society against further threats from those who had been put away and to punish offenders by cutting them off from normal life. The purpose of imprisonment began to be seen as rehabilitation, and the prison as a means to re-educate the offender and prepare him for return to the community. The reformatory at Elmira, New York, established in 1869 to receive youthful and first offenders, pioneered in this approach. Instead of being herded in idleness, prisoners learned trades and engaged in useful work during their stay in the institution.

The concept of rehabilitation carried with it implications for the length of the sentence. If the object of incarceration was to give the offender an

opportunity to readjust to normal life, the length of his sentence should be related to the success of the rehabilitation process rather than the offence for which he was committed. The system of parole was designed to carry out this idea. If the prisoner showed evidence by his behaviour and progress in the institution that he was ready to return to society, he might be released conditionally under the supervision of a parole officer for the remainder of the term for which he was committed. The parole officer or other agent had the further responsibility of helping the released prisoner to adjust to normal life.

Twentieth-century developments in the treatment of adult offenders elaborated the concepts and procedures for rehabilitation which the prison reform movement of the late nineteenth century had established. The developments followed a common pattern although countries varied from those where trends were apparent only in a few steps taken by an exceptional institution to those where the entire penal system was characterized by the new approach.

Refined techniques for screening prisoners by means of psychological and social study were used to differentiate the ones more likely to respond to positive programmes of rehabilitation. In some countries, notably France, prisoners committed for a term of two or more years were sent first to an institution where they could be studied and observed before being assigned to the penal institution judged most suitable for their treatment.

With the objective of preparing the prisoner for return to community life the historic policy of cutting him off from normal contact by imprisonment was replaced by one of maintaining as much continuing relation with the community as possible. Prisoners in advanced institutions, particularly in the Scandinavian countries, worked for pay, frequently for employers outside the institution on terms consistent with prevailing wages and often arranged by the prisoner himself. Their earnings were devoted, under different systems, to payment for their board in the institution, support of their families, restitution in connection with the offence for which they were committed, or were placed in a fund which would tide them over the period of readjustment upon their release. They might receive furloughs to visit their homes periodically, or spend the latter part of their stay merely sleeping at the prison while they enjoyed the facilities of the community for work and recreation during the day.

Opportunities to develop responsible behaviour were provided through the internal organization of the prison on a self-governing basis and in the educational responsibilities carried by some prisoners on behalf of others to whom they taught literacy or trades. Through the co-operation of outside educational institutions prisoners could take advantage of correspondence courses. In some countries camps or farm colonies where prisoners could have their families living with them were established experimentally. Fixed sentences were replaced by indeterminate sentences subject to administrative decision or determination by a parole board as to whether the prisoner should be longer detained or had shown such response to treatment as to be ready for release.

These developments in procedure were accompanied by constant study at many different levels in the attempt to gain understanding of the variety of factors entering into criminal behaviour. In general such studies followed lines similar to those developed in the study of juvenile delinquency. They attempted to distinguish between those whose behaviour arose from essentially psychological causes and those where social factors predominated; they sought to provide specialized treatment for the former, and to use both the experience in the institution and the manner of return to the community to attempt to cope with the latter. Success of measures for the rehabilitation of offenders required the sympathetic co-operation of members of the family and community. A major part of all programmes for prisoner rehabilitation included measures to modify public attitudes and to work with families and neighbours toward acceptance of the released prisoner and support for his own efforts at rehabilitation.

Measures to improve the treatment of adult offenders, however, were constantly undermined by high rates of crime which tended to reflect growing urbanization, the strains and disorders of wars and depression and the new mobility provided by the automobile. Since modern individualized practices in prison treatment could only be used with relatively small numbers, the mounting numbers of inmates, crowding of prisons and shortages of personnel impeded their application. In most countries scientific technology was far more systematically applied to the detection of crime than were the best known practices to its treatment or prevention.

4. *The disabled and handicapped*

Persons suffering from physical and mental handicaps, either from birth or as the result of injury or illness, constituted a substantial proportion of the population of every country. Programmes for these handicapped groups aimed to make them able to function as fully as possible in normal society.

Child welfare services generally included special provisons for blind, deaf, crippled and mentally defective children. As far as possible they were kept in their own homes and were provided with services to remove or compensate for their handicap, to help them to grow as nearly as possible like and with normal children, and to enable them to function at their highest capacity. Improved techniques for the training of deaf-mutes and blind, orthopedic surgery, prosthetic devices and retraining of the muscles of cripples, accompanied by help in the psychological adjustment to the handicap, ensured to an increasing proportion of such children the opportunity to live fully as participating members of society. Mentally defective children who appeared to be too severely handicapped to have the prospect of becoming self-sustaining were cared for in special institutions, but these agencies, too, developed techniques for training according to the degree of disability, with the object of returning to the community some who would formerly have been considered hopeless.

The extraordinary career of the blind deaf-mute, Helen Keller (1880–), who learned to communicate with others and wrote, travelled and spoke throughout the world, offered an inspiration and stimulus to efforts in many countries. Specialized personnel was trained to utilize new techniques as they were developed. Electronic devices permitted the development of a variety of hearing aids which removed the bar of deafness from many with very limited hearing. Sight conservation programmes involving special classes in school, special glasses, treatment and sometimes surgery, aided the visually handicapped; together with measures to eliminate such diseases as trachoma and congenital syphilis, they helped to reduce the incidence of blindness. Libraries included sections devoted to books printed in Braille, the raised type invented in France in 1834, and to 'talking books' on gramophone records. Organized programmes for training guide dogs gave many blind persons mobility and independence. Programmes of economic aid to the blind or disabled made it possible for them to live in their own homes and largely eliminated the need for institutional care.

Rehabilitation of handicapped adults received a great stimulus from the impact of the wars, especially the second world war, both because of the programmes developed for disabled war veterans and because the extremely heavy demands for labour in wartime forced the use of handicapped persons who would not normally have been employed, and revealed their capacities for useful work. In most of the European countries legislation required employers to include in their work force a certain proportion of disabled persons, sometimes specifically war-disabled, ranging from 2 to 10 per cent of their employees. Elsewhere, especially in North America, Sweden and New Zealand, employers were encouraged to follow a similar course voluntarily by public appeals and by the work of special placement officers attached to employment services.

During and after the second world war the physical restoration of injured and maimed persons was developed to the point of becoming a medical speciality for which special training was offered in a number of medical schools in the United States and a special diploma in the United Kingdom and Canada. For the maimed, research in Germany, the United Kingdom and the United States resulted in the perfection of very delicately adjusted devices and methods of training the wearer in their use.

Psychological adjustment and vocational retraining or guidance proved of equal importance with physical restoration in enabling the physically handicapped to shorten their hospital stay and to become able to work and take care of themselves. A combination of job analysis to determine the actual demands on the worker made by specific jobs, and the careful determination of the handicapped person's capacities through the use of psychological and physical tests and through observation of his performance under simulated work conditions in diagnostic or training centres, provided the basis for vocational counselling and guided the individual to appropriate training and job placement.

For the most severely limited, who could not work under normal conditions, private organizations in a number of countries conducted sheltered workshops or provided work to individuals in their homes. The USSR maintained a wide network of technical vocational boarding homes and specialized secondary schools to train handicapped or disabled persons and to place them in employment in accordance with their condition.

All these measures combined to lessen the isolation of the handicapped and the waste of their energies.

5. *The mentally ill*

The new understanding of mental illness, together with the growing number of persons recognized as mentally ill, stimulated preventive efforts and programmes designed to restore such persons to normal life.

The mental health movement sought to establish among the general public concepts of mental health and illness based on the best available knowledge, to encourage the application of mental health principles in daily life, to support the establishment of facilities in the community and encourage their use by those needing psychiatric attention, and to create an atmosphere which would facilitate the return of recovered patients to community life and their sympathetic acceptance by employers, family and associates.

The mental health movement received a strong stimulus from the publication in the United States in 1908 of the autobiography of a mental patient who had recovered after experiencing harsh and brutal treatment in three different types of mental institutions.* The revelations of this book, and the tireless efforts of its author to arouse public interest and understanding, led to the formation of a National Mental Hygiene Committee in the United States in 1909, similar committees in states and local communities and the International Committee for Mental Hygiene in 1930. The concept of 'mental hygiene' brought out into the open, for public discussion and recognition as a problem of health, what had long been regarded as something dark and evil.

The first effect of the mental hygiene movement was to speed the conversion of 'insane asylums', where those presumed to be permanently unfit for society were herded, into 'mental hospitals' where ill persons were treated with the hope of returning them to society. Public exposures of conditions in these institutions brought enlarged appropriations for their support and professional direction to their administration.

Along with efforts to improve mental institutions went the establishment and great expansion of community mental health facilities for diagnosis, treatment and prevention. Chief among these were child guidance centres. Following early experiments before the first world war child guidance clinics were established in the 1920s in a number of places, many of them stimulated by grants from an American foundation, the Commonwealth Fund. These clinics were at first closely associated with efforts to understand and cope with

* Clifford W. Beers, *A Mind That Found Itself* (Longmans, Green & Co., New York, 1908).

juvenile delinquency; most children were referred by juvenile courts and the clinics dealt primarily with overt behaviour problems. Later emphasis was on the detection of early symptoms of maladjustment before the child's difficulties should reach a point where he would become a court case. Child guidance clinics were introduced into schools and made part of general community health services and teachers and parents were alerted to recognize in the silent, withdrawn child one who might be as much in need of help as the aggressive child whose behaviour earned attention.

Community clinics for adults and psychiatric services outside mental hospitals developed more slowly than mental health services for children, except for the psychoanalytical treatment of private patients able to pay the very high costs of such service in the major cities of Europe and America. Impetus to the extension of psychiatric services for adults came from the military services. In an effort to avoid a repetition of the experience of the first world war, in which large numbers suffered what was then known as 'shell shock', the armed services in the second world war attempted to screen recruits in order to eliminate those who appeared likely to break down under combat strain. On this basis more than 10 per cent of those called up by the United States army, for example, were rejected because of neuropsychiatric disorders; nevertheless, approximately a million of those accepted for military service were hospitalized for such disorders during the war.

In the face of this evidence of the widespread incidence of neuropsychiatric difficulties, psychiatric services began to be introduced into a wide variety of settings. Some large employers started to offer such services to their personnel, universities added psychiatric clinics to their student health services, psychiatric services were introduced into the more modern prisons and special clinics were established for alcoholics as chronic alcoholism came to be recognized as a symptom of mental disorder.

The shift in the approach to alcoholism was one of the major fruits of the mental health movement. Excessive use of alcohol, beyond that tolerated by social custom, had long been a recognized problem. Among the social reformers of the nineteenth and early twentieth centuries in Europe and North America, none were more vigorous than the leaders of the temperance movement who conducted a broad attack on the 'demon' drink. Their approach was a moral and punitive one—admonish the worker who wasted his weekly wage by getting drunk on Saturday night, withhold charity from his family unless he reformed, put him in jail for drunkenness, close the saloons that placed temptation in his way and forbid the sale of intoxicating liquor. These efforts reached a climax in the complete prohibition of alcoholic beverages in Norway in 1916 and Finland and the United States in 1919, with disastrous results, especially in the last country, in the development of illegal traffic but little success in coping with the problem of alcoholism.

Although in the early years of the century alcoholism was beginning to be seen as a problem of health and not simply of morals, the Health Committee

of the League of Nations, in 1928, found public awareness of this insufficient to lead it to undertake an active programme in the field. In the 1930s, however, alcoholism came to be recognized increasingly as a means of escape from intolerable psychic strains with which the individual could not cope, and the alcoholic was seen as a person in need of psychotherapy rather than repression.

Following establishment of the first experimental alcoholic clinic at Yale University in the United States in 1940, special clinics for alcoholics were set up by mental hygiene agencies in several countries or were attached to general hospitals. In some circumstances these were closely linked with the penal system, attendance at the clinic being offered to an alcoholic prisoner as an alternative to a jail sentence, but since the effectiveness of clinical treatment was presumed to depend upon the co-operation of the patient, treatment was not generally compulsory. The World Health Organization in 1950 established a committee on alcoholism as a sub-committee of its Expert Committee on Mental Health, to stimulate research into stages and types of alcoholism and to encourage national health services to make the prevention and treatment of alcoholism an essential part of their public health programmes.

Spontaneously formed groups of former alcoholics themselves undertook to provide social support for the alcoholic who was striving to free himself from the need for this manner of escape from reality. Under the organizational name of 'Alcoholics Anonymous', established in the United States in 1932 and extending to other countries, many such groups helped to provide members with the social recognition and self-esteem which they needed and mutual support in their efforts at rehabilitation.

Efforts at prevention of mental illness took the form mainly of educational programmes and the dissemination of information through the public press, magazine literature, radio programmes and films. Films designed to disclose factors leading to mental disorder and to acquaint the viewer with methods of treatment were developed in Canada and elsewhere, and were used as the basis of discussion by parents, teachers, trade unions, churches and other groups. On the whole these programmes reached principally the better educated and younger members of the community, and by the 1950s the views toward mental health held by this segment of the population were generally in accord with those held by experts. Some programmes of mental health education were introduced into schools on an experimental basis. Participants in a Unesco-sponsored conference on Education and Mental Health in 1952 found programmes worthy of note in Denmark, Canada and the United States which attempted, through direct discussion of human relations or the infusion of such materials through the school curriculum, to give children some understanding of their own and other people's motives and to help them to grapple with their emotional problems as they arose rather than to repress them.*

Nearly everywhere, however, shortages of facilities and personnel stood in the way of adequate treatment and care for the mentally ill. Children's clinics

* W. D. Wall, *Education and Mental Health* (Unesco, Paris, 1955), p. 294.

frequently limited their services to diagnosis in the effort to single out those needing intensive treatment and to offer such help as the diagnostic process alone could render to the parents of children whose difficulties were not deep-seated; but even on this basis waiting lists for treatment were long and involved delays of many months. The extreme shortage of personnel—psychiatrists, psychiatric nurses and social workers, occupational therapists, special teachers for emotionally disturbed children, psychiatrically oriented hospital attendants—was accentuated by the concentration of such specialists in a few centres, such as Vienna, New York and other major cities. Large areas lacked any professional psychiatric worker, even in the United States where interest in mental health reached its height during these years and the number of psychiatrists was substantially increased by German and Austrian refugees in the 1930s.

In spite of reforms few public mental institutions in any country were able to offer care and treatment commensurate with the level of knowledge and understanding. Although the brutality which had been a feature of most mental institutions prior to the twentieth century largely disappeared, neglect remained, for in understaffed and overcrowded hospitals, where one psychiatrist might be responsible for as many as 500 to 1,000 patients, there was little opportunity for careful treatment leading to rehabilitation. It was estimated in the mid-1950s that as many as 10 per cent of all the patients in mental hospitals in the United States would be discharged if hospital personnel were sufficient to handle their problems and other community facilities were adequate.

Rehabilitation of the mentally ill, moreover, continued to be hampered by community attitudes and by the absence of other types of community services. Families continued to reject members whom mental hospitals thought ready for discharge and employers often hesitated to give them work. Where hospitals encountered such attitudes and could find no foster home to receive a patient in the absence of a suitable or willing family, they were forced to keep patients who did not need continued hospital treatment. Lack of such services as nursing homes for old people not requiring psychiatric care prevented the discharge of others.

At mid-century the attack on mental illness was being intensified from all directions. The third International Mental Health Congress, held in London in 1948, led to the formation of the World Federation for Mental Health and the World Health Organization established a mental health section dedicated to the effort to bring about wider recognition and application of principles of mental health.

All the programmes which served the physically or mentally handicapped or the physically or mentally ill were guided by a common principle—that the individual's remaining capacities, whatever they might be, rather than his lacks, were the necessary basis for his rehabilitation and functioning. By exploiting these positive factors society could gain an asset rather than being

burdened by a liability, and individuals could enjoy satisfaction and self-esteem. Much of the research, organization, training of personnel and interpretation to the public was oriented toward ways to recognize such positive capacities and to work with them.

6. *The aged*

In the twentieth century, for the first time in history, a large proportion of the population in industrially developed countries lived to old age. At the mortality rates of earlier times, and those which still prevailed up to the middle of the twentieth century in many areas, only a small minority of those born reached late maturity or old age. In the twentieth century the average life expectancy at birth in the industrialized countries increased by some twenty years and at mid-century it exceeded 65 in most such countries.

In 1900, there were only three countries, Sweden, France and Norway, where more than 7 per cent of the people were over 65. In 1950, those over 65 constituted from 7 to 12 per cent of the population of nearly all of the European countries as well as Canada, the United States and Australia. In New Zealand it exceeded 15 per cent.

The great increase in the number of old people and in their proportion in the population coincided with economic and social changes which disturbed their customary status and role, their means of livelihood and their prestige.

The rapidly changing urban-industrial society placed the older person at a disadvantage. It put a premium on the qualities of adaptability and alertness, more often found in younger workers; it tended to make obsolete many learned skills; it drew a sharp line between the fully employed and the unemployed, leaving little room for the tapering off of economic activity and the adjustment of tasks to waning strength which kept the ageing rural worker usefully engaged. Older people were left outside the small family of parents and children instead of enjoying the respect and often authority that came with age under the large or joint family system. The rapidity of social change made old people no longer the repositories of knowledge and wisdom but more often the holders of obsolete ideas and standards. Small city dwellings and the world-wide shortage of urban housing crowded them out of living space.

In these circumstances the growing number of aged people constituted a burden of economic dependency as they were forced into retirement and as a series of severe inflations reduced the value of their savings and pensions. Their presence created a potential source of strain, both on themselves as they tried to hang on or to adjust to retirement in a work-centred society where to be employed was to belong, and on younger people who feared that their own advancement would be blocked or that unduly conservative policies would be sustained. Although the problem of the aged was only one among many social problems created by the spread of the urban-industrial way of life, it was of growing magnitude and became the focus of more and more conscious attention and professional effort during the period.

The first aspect to receive attention was economic—the needy aged without employment or means of support. Nearly every government in the world took some steps toward meeting the problem of income for the aged. Some twenty countries adopted special programmes of public assistance to aged persons in need, nearly fifty included old age benefits in their programmes of social insurance, and a few, notably Canada, New Zealand, Holland, Norway and Sweden, provided pensions to all citizens who reached a certain age.

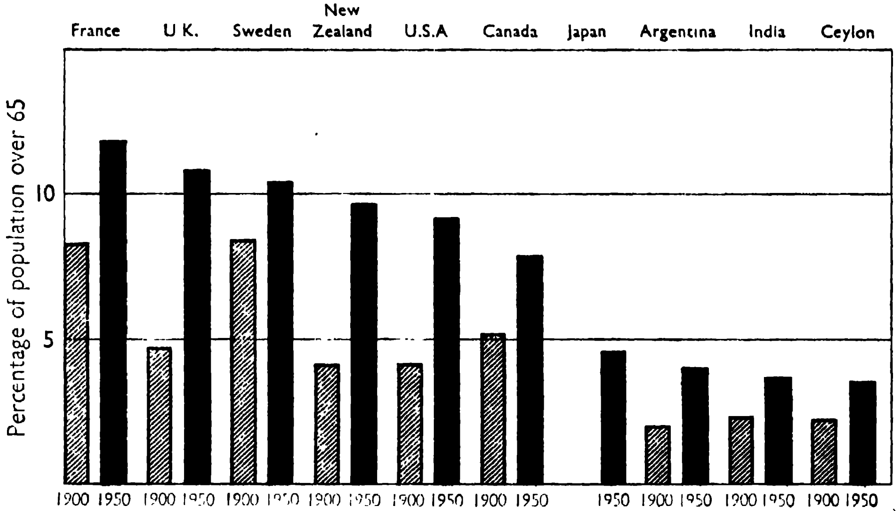

CHART XXIII. Percentage of Population over 65, 1900 and 1950. Selected Countries

Source: UN, *The Aging of Populations*, 1956.

A growing proportion of all old people in the industrialized countries received one or another of these benefits; where social insurance programmes were expanded to include additional categories of workers, a still larger proportion of younger people expected to receive benefits when they reached the age of eligibility. At mid-century somewhat less than half of the people over 65 in Great Britain and the United States were receiving insurance benefits or assistance grants, while virtually all British workers below that age and more than 85 per cent of Americans were covered by social insurance and could expect to draw benefits in the future. USSR state pensions covered all factory and office workers and servicemen, together with their families, while collective farms set aside a portion of their crops each year to provide a pension fund for their members.

In addition to general social security coverage, special pensions were paid in most countries to a number of groups such as government workers, military personnel and teachers, and were provided by industries for their employees

as a result of collective agreements or voluntary action. Most people in industrialized countries were able to look forward to a continuing income after retirement from work and to freedom from dependence on their children for minimum support.

Toward the middle of the century, however, it became apparent that income was only one of the needs of aged people and that a multitude of other social and health problems required solution if the growing body of older people were not to constitute a drag on industrialized societies. At the same time the approach to the needs of the aged shifted from the negative one of providing income and care for those who were on the shelf, to a positive effort 'to add life to years, not merely years to life'.* By the middle of the twentieth century there was a strong and growing movement to enable the aged segment of the population to live productively, and with health, comfort, enjoyment and self-esteem.

At this time gerontology, the study of all aspects of ageing, emerged as a specialized field of professional endeavour. In medicine, geriatrics, the study of the diseases of ageing, had been recognized as a special field since the publication of the first textbook on the subject in 1914.† Following the organization of gerontological societies or the establishment of special councils or commissions in a number of countries, the first International Congress of Gerontologists was held in Belgium in 1950, followed by successive international conferences in the United States, Great Britain and Italy and a Pan-American conference in Mexico in 1955. The approach was many-sided and involved members of a number of professions.

In the interest of physical and mental health and social adjustment, efforts were concentrated on prevention of chronic illness and premature senility and on the physical and social rehabilitation of many whose years of usefulness and self-maintenance appeared to be over. Elderly people were absorbing an increasing proportion of the time of physicians as evidenced by the British experience under the National Health scheme, where patients over 65 averaged 40 per cent more medical consultations per year than adults below that age. Numbers of beds in general hospitals and mental institutions were occupied by chronically ill old people who did not need complete hospital care. To meet this situation a variety of measures were instituted to make it possible for old people not in need of hospital care to avoid hospitalization.

The traditional means of caring for the aged outside the family group was in old people's homes, and almost every country, whether industrially developed or not, had some such institutions housing from 2 to 7 per cent of their older people. In line with trends in the care of other groups, institutions which gave only a minimum of custodial care came to be regarded as unsatisfactory. There was a general movement to reduce the numbers of old people

* See Lord Basil William Amulree, *Adding Life to Years* (London, 1951).

† I. L. Nascher, *Geriatrics: The Diseases of Old Age and Their Treatment* (Blakiston's Son & Co., Philadelphia, 1914).

needing to go to an institution and to raise the standards of service for those requiring such care.

Some countries developed large well-equipped centres such as the Old People's Town in Copenhagen, with its own hospital, assembly hall and church, manned by a staff of 500 to look after its 1,600 residents. The USSR maintained special homes with workshops, social amenities and medical services. In some places, notably in Great Britain and the United States, the trend was toward small specialized nursing or boarding homes less isolated from the rest of the community.

Principal efforts, however, were directed toward making it possible for old people to live in homes of their own and to continue to function as actively as their strength would permit.

Hospitals in Great Britain and the United States were beginning to develop programmes of home care as an extension of their regular service. On the basis of the great success achieved during and after the second world war in the rehabilitation of very severely handicapped military personnel, physical rehabilitation and retraining was undertaken for many civilians, including aged persons, whose situations had seemed hopeless.

Housing was a difficult problem for older people who either had no family with whom they could live or for whom there was no room in their children's small apartment or house; a 1954 British study of persons over 70 found 43 per cent with no members of their family alive, no contact with family members or only a very weak or poor relationship. Housing projects for independent old people began to be constructed in a number of countries, initially in Norway, Sweden, Denmark, Britain, Holland and Canada. At first these were separate blocks of flats, but later they were built as integral parts of housing developments for a cross-section of the population in order that the aged might not be segregated from the community. In addition various housekeeping services such as prepared meals sent in to aged persons who could not cook for themselves, and laundry, mending and other forms of home-help were established and expanded rapidly, especially in Great Britain and the Netherlands.

Opportunities for earning at least a partial income were provided by the sheltered workshops and work for the home-bound established through voluntary organizations in many countries. Advisory services to help aged people to know the possibilities for retraining, employment, housing, recreation or medical care were provided in connection with most pension or other schemes for financial aid and by other social agencies.

By these measures and through the specialized research and attention of doctors, psychologists, sociologists, social workers, psychiatrists, educators and others, and through a shift in community attitudes, a beginning was being made at mid-century to transform what was regarded as the 'problem' of the aged into positive efforts to enhance the potentialities of this large and growing sector of the population.

III. ECONOMIC AID TO FAMILIES

In addition to making provision for various dependent groups, industrial countries took steps to equalize the situation of children growing up in families of different size. Under conditions of modern urban living the economic burdens carried by families in the rearing of their young came to be recognized as heavy, especially for large families. In agricultural societies additional children were often economic assets because of their ability to contribute at an early age to the productive work on which the family's living depended. Under urban conditions they were a liability, particularly since child labour laws restricted their employment.

In order to assist families in meeting their economic obligations countries in many parts of the world enacted legislation which took account of the differential economic needs of large families as compared with those which had few children or none. Such measures were not designed to replace income lost by reason of one hazard or another, as were social security benefits, but rather to supplement the regular family income. When the United Nations made a survey of *Economic Measures in Favor of the Family* in 1952, it found that such measures had come to make up the skeleton of a special scheme within the sphere of social welfare. In spite of the haphazard manner in which many of these measures had been introduced and the fact that some were organically connected with social insurance, some with assistance programmes and some were independent measures, taken as a whole they established a distinct principle: differential economic benefits for families of different sizes.

The most general of these measures were family allowances which added to the level of family income in relation to the number of children. These had been established by 1950 in some form in most industrial countries with the exception of the United States. Family allowances developed in different ways in different countries. In France and some other countries of continental Europe they were introduced by employers as a means of resisting labour's demands for a general raise in wages. When applied on an individual plant basis, however, a wage differential in favour of the heads of large families worked hardship because it made it economically advantageous to the employer to take on persons without dependents to do the same work for less pay. In order to avoid this dilemma industry funds were pooled and the wage supplements were paid out of the common pool so that the individual worker did not cost the individual firm more because he received an allowance.

Elsewhere, notably in the Scandinavian countries, family allowance plans were introduced in the 1930s because of concern over the low birth rate in urban areas, and were paid out of the public treasury, not industry funds. The Canadian scheme was inaugurated at the close of the second world war, primarily on the initiative of the business community which feared a post-war economic slump and saw the steady though small increments provided by the

family allowance as a means of sustaining buying power and thus contributing to the stability of the economy.

Whatever the circumstances of their introduction, allowances were generally available to families without a means test, though the additional income which they represented was usually cancelled through progressive taxation above a certain income level; in no instance were they sufficiently large to provide for maintenance. In some countries grants were paid for all children while in others they began with the second or third child. In the USSR monthly grants for children from birth to the age of five began with the third child and increased with the size of the family; unmarried mothers received a grant at the birth of the first and every succeeding child. Some countries continued payments until the child reached sixteen; they differed in whether they maintained the size of the grant at a uniform rate or modified it upward or downward with the age of the child and the number in the family.

Virtually every country which collected an income tax allowed a tax deduction for each dependent. A few countries had special benefits such as marriage grants and birth premiums to facilitate the setting up of new families and help to defray the additional costs of pregnancy and birth.

In addition to measures of direct financial supplement or tax relief, some countries made special provision for food, housing and other necessities in such a way that direct expenditures were unnecessary or the family with a number of children had to spend less for the equivalent goods and services than others. Illustrative of such measures were special meals for school children, vegetable garden allotments on the outskirts of towns, larger dwellings for large families at lower cost as in Sweden, or priority in the allocation of new housing as in the USSR, rent allowances, rebates on gas and electricity, provision of certain types of clothing. Special concessions with respect to fares for children or families travelling together were quite common, including in some countries provisions to make it possible for families to take holidays or engage in recreation together; Sweden even provided holiday allowances for housewives and free holiday transport for housewives and children. These measures lessened the economic disadvantages for the child in a large family as compared with a small family of similar occupational status.

IV. PRINCIPLES AND METHODS OF SOCIAL WELFARE

Underlying the measures to deal with dependency and to promote social welfare in all fields ran a common set of evolving principles and common tendencies in the choice of methods employed.

1. *Respect for the individual and confidence in his potentialities*

Twentieth-century social services were based on a fundamental attitude toward the individual: respect for him as a person and the belief that he had within himself potentialities for development and responsible action. In tradi-

tional liberal and democratic societies this meant the application of the central principle of such societies to elements in the population who had in actual fact been denied or only grudgingly accorded this dignity. In traditionally authoritarian and stratified societies such an assumption was part of the revolution in outlook which was taking place. In communist societies it reflected the assumption that the individual could and must function as a rational component of society and would respond to education and persuasion, though the need to maintain the social fabric intact might require a resort to punishment or exclusion as a temporary device. The development of this attitude toward the individual, and its infusion into public consciousness, into legislation and into the practice of those entrusted with carrying out social measures gave welfare programmes their most basic significance.

Social work practice recognized the individual's strong qualities, whatever his limitations might be, depended on his co-operation on his own behalf, had faith in him and in his ability to use his positive capacities and helped him to respect himself. This fundamental approach completely reversed the punitive and morally superior attitude with which charity had often been offered. Observing the beginning of this shift at the opening of the century, one of the founders of the social work profession in the United States, Mary Richmond, commented: 'In nothing does the change seem so marked as in our willingness to cooperate with the poor themselves and with their neighbours.'* In the following years the changed attitude came to be based not alone on the changing social and moral climate but also on a practical understanding of human psychology and motivation which indicated that only through his own active participation could the individual make full use of whatever services were offered, achieve his own rehabilitation or prevent his own distress.

In line with this attitude, the distinction between the general population and those who were the recipients of public aid was broken down. The 'poor', the 'needy', the 'dependent', the 'insane', the 'criminal' or 'delinquent', the 'aged', the 'illegitimate', not only came to be regarded as citizens with rights, feelings and dignity but to be treated by methods which as far as possible enabled them to retain their status and participate in the life of the community.

2. *Changing focus of social programmes*

The content and focus of social programmes shifted by successive stages from mere relief of distress, custodial care or punishment to measures for positive welfare. The first stage was the introduction of the idea of treatment and rehabilitation, which provided the foundation for the juvenile court and the reform of juvenile and penal institutions, for the conversion of mental institutions from custodial agencies to treatment centres, and for the services of social workers as counsellors in family welfare agencies, public assistance offices, clinics and hospitals. Along with the emphasis on treatment went a growing trend toward prevention rather than cure. Social insurance against

* *Charities*, vii (September, 1901), p. 191.

the major hazards likely to cause poverty and dependency—accident, illness, old age, disablement, death—became a characteristic feature of modern states; measures such as economic aid to larger families and parent education and counselling were adopted to prevent family breakdown; programmes to deal with juvenile delinquency focused on the detection of early symptoms of maladjustment.

As preventive measures were extended it became apparent that a negative approach was insufficient, and social programmes took on a positive orientation, well evidenced by the shift in focus of the decennial White House conferences on children in the US from 'the care of dependent children' in 1909 to 'a healthy personality for every child' in 1950. Services for all the people increasingly replaced programmes for dependent or insured groups, as comprehensive health programmes replaced limited health insurance and medical care for the indigent, public education was broadened and public facilities for recreation were extended.

The scope of social programmes broadened in every direction—in the hazards against which protection was provided, the range of people enjoying community services and the types of problems to which community resources were devoted. Most especially they came to include non-material as well as material needs.

By the middle of the twentieth century those responsible for social welfare in industrial countries were greatly concerned with the psychological strains of industrial society, for they were coming to recognize that the psychological effects of industrialization were cumulative. The older industrial societies were still heavily burdened by the psychological results of the poverty, indignity, social disorganization, crowded living and abuse of children which had characterized the earlier stages of their economic growth. Persons who had been raised in homes which could not give them the security of a stable society had in their turn been unable to provide their own children with the stability necessary to adjust to constant change. In spite of improved conditions, moreover, there remained an unresolved conflict between the stable, rational and responsible behaviour expected of the individual as a parent and citizen and the conduct required of him as an industrial worker, engaged in impermanent work under outside direction, faced with constant threats to his status from technological change and occupying an assigned role which tended to decline with advancing age.

The central social problems of industrially developed countries came to lie in the area of human relations, human satisfactions and human dignity.

3. *Changes in structure and design*

These basic changes in the character of welfare services were paralleled by changes in structure, auspices, techniques and the locus of responsibility. The same methods continued to be used: private philanthropy, public assistance, social insurance, establishment of minimum labour and living standards

by law, and the direct provision of public services; but they changed in relative importance and in the part played by each in total welfare developments.

Private philanthropy lost its central role and its capricious and paternalistic character even in the countries where it was most widely developed and continued to flourish. Although often not subject to the same standards of impartiality as public services, private agencies generally came to occupy a specified place in an integrated and planned community effort, supplementing broad public services by meeting special needs, providing an opportunity for experimentation or serving special groups.

Public assistance largely replaced private philanthropy as a source of economic aid. At the same time it ceased to be granted as a benevolence and became a matter of right. Those who met legally established criteria of eligibility were entitled to aid, and the public assistance laws of the second quarter of the century generally confirmed this right by providing for appeal in case relief was denied.

While public aid took the place of private philanthropy, assistance based on evidence of need was in turn largely replaced by social insurance and preventive measures. In most countries assistance was retained as a supplement to these more comprehensive programmes. Some of the countries with the broadest welfare programmes such as New Zealand, however, chose to use generous social assistance for many contingencies in preference to contributory social insurance.

The most widespread expansion came in the development of social insurance systems which had only begun to spread from their German origins at the opening of the twentieth century and which were established in some form in virtually every country in the world by the 1950s. These systems generally began with small programmes covering limited groups of industrial workers and few hazards and were expanded until in some industrial countries they embraced virtually the entire working population in industry, agriculture, trade and services and included all types of risk. By 1956, 71 countries had adopted insurance programmes against work accidents, 49 provided for the maintenance of income during old age or after the earner's disablement or death, 45 countries, including every industrialized country except the United States, had health and maternity insurance to cover medical costs and usually to provide income during illness. The famous Beveridge Report in Britain, published in 1942,* which set the goal for that country as protection 'from the cradle to the grave', completely abandoned the old poor relief concept that the threat of near starvation is necessary to force people to work, and substituted the opposite assumption that insecurity is not an effective or necessary goad but tends to make people less able and less inclined to function at their best.

Social insurance systems varied in their method of financing and the relation of benefits to contributions. Benefit payments were most frequently related to

* Sir William Beveridge, *Social Insurance and Allied Services* (November 20, 1942).

the amount which the recipient had been earning, thus giving larger benefits to those whose wages were higher, though some systems provided for benefits at a flat rate or adjusted to need. Contributions were generally collected from employers and workers as a proportion of the worker's wage, partly as a means of securing the funds out of which benefits could be paid and partly to establish a claim of right on the part of the beneficiary. The state also contributed to some schemes, and there was a tendency for the state's share to increase as benefit levels were raised and more groups in the population were covered. Some countries abandoned contributions in favour of a pension out of tax funds, as did Canada, on the ground that all who reached the age of 65 after residing in the country for twenty or more years could be presumed to have contributed sufficiently to the nation's resources to be entitled to benefits. Benefits in the USSR were paid out of funds contributed by state enterprises without deductions from workers' wages, although the size of the benefit was related to wages and number of working years, adjusted upward in case of injury received in industry or military service; with the growth in national revenue the general level of social security benefits increased.

The device of using minimum standards set by law to place a floor under the working and living conditions of the people was also widely extended. The scope of labour legislation was broadened until it provided an elaborate framework of minimum wages, limitation of hours, minimum conditions of health and safety, minimum age of employment and a wide range of other conditions which industry was required to meet in order to be allowed to operate. Regulations designed to assure minimum living conditions took the form of expanded public health laws, food and drug inspection, and minimum standards of safety, space, sanitation and ventilation of housing.

The direct provision of public services as a method of meeting needs tended to reach its greatest extension in those countries committed to a socialist pattern of society and to be used less generally elsewhere. Nevertheless, the number and range of publicly provided social services grew apace in virtually all countries as one after another of the services which had been offered to dependent groups as charity were provided at public expense for the whole population. In some countries with a strong non-socialist orientation, such as the United States, a well-established tradition of public services in certain areas, such as education, libraries, recreation or public health, provided the basis for expansion in these areas, while non-traditional fields such as housing or medical care lagged behind. Elsewhere, as in many Latin American countries, the absence of any services except those publicly provided and the large proportion of the population too poor to take advantage of facilities on any other basis made for the extension of public services on pragmatic grounds rather than because of principle.

As the newly industrializing countries adopted welfare programmes they attempted to use the forms which had become established elsewhere. With few exceptions they introduced some sort of social insurance, set minimum

conditions through labour legislation and committed themselves to provide a variety of direct public services and sometimes a measure of financial assistance to those in need.

It was an evidence of the strength of the trends in these directions that legislation often went far beyond the ability of the country to finance or man the programmes which it established on any but a very limited scale or to enforce standards beyond a few key places or groups. Meantime, the benefactions of wealthy individuals, the patronage of political or social leaders, and the services of dedicated groups continued to provide many of the pioneer and fragmentary services which were actually available in these countries. India, for example, estimated that it had some 10,000 private charities when it set up a Central Social Welfare Board in 1953 to assist and co-ordinate their activities.* There were however facilities for only something like 3,000 out of perhaps two million blind, scarcely any provisions to aid an estimated seven million crippled, only four institutions in the entire country for mentally defective children and virtually no psychiatric services for children.

The problem of designing welfare programmes for underdeveloped areas was thus a twofold task of dealing at the same time with the mass problem of poverty, ill health and ignorance and the special problems of particular disadvantaged groups. In the western industrialized countries, welfare services were primarily needed by a relatively small portion of the population that fell below the general level of adequacy which most families could maintain under normal circumstances, or were unable to make a social adjustment in industrial society. In the underdeveloped countries, where the general level of living was below minimum standards of adequacy, the problem was not merely to help the laggards but to raise the majority through broad measures affecting the health, nutrition and productivity of the general population.

In these circumstances one after another of the underdeveloped countries adopted what came to be known as 'community development' programmes whose essential purpose was to mobilize the initiative of people on their own behalf and to make limited supplies and specialized personnel available where people were ready to make use of them and to supplement them by their own efforts. The community development programmes were primarily addressed to the villages and aimed to stimulate the rural populations to better their own lot. The design of the programmes varied but most of them made use of some sort of 'village worker' who knew how to work with villagers, and who was able to tap the technical resources provided by existing social programmes and sometimes to teach certain skills. In some countries their work was supplemented by that of welfare aides whose activity was primarily with the women and children. Up to the middle of the 1950s community development programmes had not been effectively developed on any large scale to meet the problems of cities and towns, though they were seen to offer possibilities.

* *Social Welfare in India* (The Planning Commission, Government of India, New Delhi, 1955).

4. *Locus of social responsibility*

The development of social programmes involved a redefinition of the respective responsibilities of the individual, family, employer, local community and the state. In spite of the general shift to social responsibility, the principle of direct individual responsibility was retained in contributory social insurance plans, in fees for services adjusted to ability to pay and in the level of eligibility for public assistance which marked the line between the responsibility of the individual and of the state. Family responsibility was retained in the frequent requirement that legally responsible relatives, if able to do so, must provide support and care, but the list of relatives whom the law tried to hold responsible was generally reduced to the immediate group of parents and children. Where families failed to meet their obligations, as in cases of desertion or failure to support children born out of wedlock, state responsibility toward the child tended to outweigh the legal responsibility of the parent and public aid was extended to children born out of wedlock or abandoned by their fathers.

Countries differed considerably in the extent to which they required employers to bear costs relating to the welfare of their workers and made protection against the hazards of workers' lives a charge against industry, but the tendency was away from the concept that industry's only obligation was to pay for time actually worked or goods actually produced, and towards a broader view of employers' responsibilities.

Employers were held responsible for far more of the costs of their workers' livelihood than in the early days of industrial development when factories used pauper children from the almshouses. Workmen's compensation laws generally made employers wholly responsible for the cost of compulsory insurance against work accidents. In most systems of social insurance against illness, disability, old age and death, employers shared responsibility with workers and the state. Under some of the early family allowance programmes the extra burden of supporting large families was charged against industry, but later systems placed the burden on the state.

In the USSR many services were provided to workers through the factory, including maternity benefits and day care for the children of working mothers, health clinics, restaurants and housing, and these were charged as expenses of the industry. Elsewhere exceptional employers established welfare services or built factory villages but in some countries labour unions opposed these as a form of paternalism and insisted that industry should put the money into wages and leave the responsibility for social services to the state. Some labour unions through collective bargaining secured contributions from employers to welfare and pension funds providing health and hospital services, retirement and other benefits for their members. Newly industrializing countries, such as India and a number of Latin American countries, tended to make industry carry many of the costs of providing security and social services to their workers.

The strongest tendency was to place major responsibility on the state and

to increase the share carried by central governments as against local units of government. Local responsibility which had characterized most of the European and North American systems was replaced or supplemented by the participation of central governments to support a national minimum standard, although actual administration frequently remained in local hands. In most countries social services and benefits came to be provided by a combination of centrally administered systems, grant-in-aid from central to local governments to supplement local resources and equalize services, compulsory insurance based on contributions from the individual, industry and the state, and a variety of voluntary efforts.

5. *The social professions*

To carry out social measures and to apply the growing body of knowledge of human behaviour, new social professions were developed and the scope of older professions was expanded by the incorporation of knowledge from social science fields. The training of doctors and nurses was broadened to include social aspects,* as was that of many teachers. Social work itself became a distinct profession. A number of quasi-professional activities were identified and several types of sub-professional or auxiliary workers were trained to supplement the professionals.

Social work as a profession was non-existent in 1900. The process of rendering aid to those in need had hitherto appeared to require no special knowledge or technique; a generous spirit or sense of duty sufficed. At the turn of the century the first formal training course was offered in New York and similar programmes were inaugurated shortly thereafter in Belgium and France. This step reflected the new idea that the effectiveness of welfare services depended upon the application of sound knowledge and the use of consciously developed techniques.

In the course of the next fifty years the profession of social work grew and spread from western Europe and the United States to more and more parts of the world. When the first International Conference of Social Work was held in 1928, a total of 111 institutions were offering professional training in most countries of western Europe, in North American and in one of the Latin American countries, Chile. In the succeeding decades schools of social work were founded in most of the Latin American countries and in India, Australia, New Zealand, South Africa, Egypt, China and Japan. A United Nations review in 1950 found 373 institutions in 46 countries; five years later the number exceeded 600.

Social workers generally assumed primary professional responsibility for services relating to economic aid, the welfare of dependent children and the social adjustment of the family and they supplemented the work of doctors, judges of juvenile courts, directors of correctional institutions and teachers; in some places they were used in industry to help workers who were new to

* See Chapter XV, Health and Population.

the ways of factory production, wage earning and city life to meet their problems of adjustment. The widespread need for trained workers in these fields led the United Nations Social Commission to give priority to the promotion of social work training through international fellowships for observation and study, the provision of social welfare advisory services and direct aid in the establishment of new schools for the training of social workers.

In the industrially underdeveloped countries the number of professionally trained workers was generally sufficient only to plan and guide programmes and to train and supervise non-professional personnel. To staff the mass services these countries experimented with ways of training large numbers of sub-professional workers to offer a minimum of service or to act as intermediaries between the professional workers and the people to be served. In a number of countries, such as India, Pakistan, Puerto Rico, Colombia, Brazil, programmes were established for the training of multi-purpose workers, village aides or auxiliary personnel in specialized fields such as nutrition, nursing or child care. The United Nations regarded the development of auxiliary-type workers as a prime requisite in the welfare fields and organized regional conferences on the subject in Asia, the Middle East and Latin America in the early 1950s.

6. *Social welfare techniques at mid-century*

When the United Nations in 1952 undertook a survey of methods of rendering social assistance with a view to determining whether there existed sufficient consensus to formulate standard recommendations to countries planning or replanning their programmes, it found common trends in principle but only a limited area of agreement in application.* The countries studied, Australia, Denmark, Egypt, France, Japan, the United Kingdom and the United States, chosen to represent all the principal systems that had been developed, used similar methods differently or in different combinations. Definitions of 'need' varied widely; although the general tendency was to broaden the concept from survival to health, and thence to the maintenance of dignity as human beings, there was no scientifically determined definition of 'need'. Governments recognized that the best defence against effects of unemployment was the maintenance of full employment, but there was as yet little information or understanding with respect to the relation between economic programmes to promote full employment and programmes of social insurance and assistance designed to prevent or relieve need.

The development of social welfare in the five northern European countries which were leaders in the field, Norway, Sweden, Denmark, Iceland, Finland, epitomized the trends of these years. There social welfare policy was gradually transformed from its traditional function of aid to those in need into a policy of social planning, centring around programmes for full and productive

* *Methods of Administering Assistance to the Needy:* Study by the Secretary General of Programs in Seven Countries (UN Department of Social Affairs, New York, 1952).

employment, family welfare and housing, prophylactic health and rehabilitation of handicapped persons. In principle the community assumed main responsibility for ensuring a decent minimum standard in fields of vital importance to the life of every citizen, at a modest level but increasing with advancement in national wealth and social thinking. Ever broader responsibilities were assumed by the state, but voluntary co-operative efforts and local initiative were also retained.

In these countries social measures increasingly took the form of public services and facilities at the disposal of the entire population. Although feelings of humanitarianism and social justice continued as driving forces for many social innovations, the main motive for these developments, according to the study sponsored by the welfare ministers of the five countries,* was the rational conviction that many improvements in living conditions for the whole or greater part of the population could best be obtained through community action. The cost of the comprehensive welfare programmes of these countries, exclusive of education and housing, amounted to from 8 to 11 per cent of national income as compared with 1 to 2 per cent for corresponding services at the opening of the century. Other countries with advanced social programmes, such as Great Britain and New Zealand, were also spending an estimated 10 per cent of their national income for similar services. The well-developed social programmes of these countries marked the direction in which other countries were moving.

Yet in spite of noteworthy developments the best available knowledge from the social and biological sciences was rarely fully and systematically applied and wide gaps in knowledge remained to keep the provision of welfare services an essentially pragmatic activity. Though there was much agreement in principle and acceptance of common approaches and standards, there was still little tested evidence of the effectiveness of various forms of social treatment and prevention. A large body of research threw light on the nature of many social problems. Agencies responsible for the administering of social security programmes and for providing social services set up what came to be called 'operational research' as an integral part of their administration in an effort to know how the programmes were being used and to provide a basis for making them more useful. Yet up to the middle of the century few well-tested techniques had been devised for evaluating social welfare programmes in terms which went beyond such elementary facts as survival and the incidence of detected illness and crime. Tests were yet to be evolved which could accurately determine how far and under what conditions specific programmes and methods of carrying them out prevented social breakdown, achieved successful and enduring rehabilitation and contributed to positive individual and social health and the maintenance of human dignity.

* *Freedom and Welfare: Social Patterns in the Northern Countries of Europe*, ed. George R. Nelson and others. (Ministries of Social Affairs of Denmark, Finland, Iceland, Norway and Sweden, 1953.)